# EFFECT OF ABSORPTION REFRIGERATION SYSTEM ON POTATO CHARACTERISTICS

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## ABSTRACT

*The changes in potato charactristeics as a function of storage temperature and time were evaluated for different quality parameters ( physical: dimentions; chemical: reducing sugars, starch,, titrable activity mechanica :weight, firmness and physiological: sprouts). under using the solar diffusion absorption refrigeration system during storage period ( two months). .The main results of this research work can be concluded and summarized as follows:-*

*The potato length ,width, thickness, spherical shape, weight, firmness, decreasing by 5.21, 10, 11.19,12.96,9.2% after cooling storage period respectively while infected and sorputs potato percentage and sugar concentration increased to 11.76% and 15% after cooling storage period.*

## INTRODUCTION

Potato is considered one of the major vegetable crops that widely used as food stuff all over the world. It is usually planted three times a year. The cultivated area in Egypt is about 200 000 feddans yearly producing about two millions mega gram (Mg) with an average yield of 10.3 Mg/ feddan according to Agriculture Research Center (2004). **Nourian et al. (2003)** examined the potato tubers for sprouting over the entire storage period. They found that the time at which the sprouts were first noticed, generally indicating a logarithmic decrease in sprouting time as a result of higher storage temperatures. Sprouts appeared after 14, 28, 62, 112 days storage at 20°C, 16°C, 12°C, 8°C respectively. At 4°C, no sprouts were observed with in the duration of the test (about 140 days) and potatoes remained healthy (no visible spoilage). Potatoes spoiled after 133, 75, 35 and 21 days of storage at 8°C, 12°C, 16°C and 20°C, respectively. **Chourasia et al. (2004)** found that the loading density of potato in stack and cold storage (534.63 kg/m$^3$ and 366.01 kg/m$^3$, respectively was optimum. The percentage free space was adequate and found to be 31.54%. Therefore, centre-most potatoes achieved safe temperature (12-13°C) in about 10 days and the

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maximum cool-down time was about 30 days. Hence, the potatoes were safe from the rotting. Also, the temperature of potatoes at the surface was always above the critical temperature for cold injury. **Chourasia et al. (2005)** found that the effect of RH on rate of moisture loss was more pronounced at the lower range of RH (75-80%) than at the higher range of the same (90-95%). A 5% increase in RH would decrease the rate of moisture loss by 0.45 and 0.437 g water/kg of potato per day in the range of 75-80% and 90-95%, respectively, at a temperature of 23.6° C. Decrease in the storage air's RH from 95 to 75% would increase the moisture loss by 5.43 and 5.76 times at 23.6 and 2.1°C, respectively. **Eltawil et al. (2006)** stated that traditional storage practice in Egypt, the bulk of potato storage takes place in traditional structures or Nawallas made of mud bricks. Nawallas are typically privately owned and are concentrated in the northern governorates with lower average temperatures. Walls are typically from 2.5 to 3.5 m high and 0.3 to 0.6m thick. Storage period is normally for 5 months, May to September. **Saad (2006)** studied the change in some physical and mechanical properties of some verities of potato during storage. This experiment excused under two storage systems (Nawalla and cold storage) temperature was 15 to 20 °C and 75% RH in Nawalla and 4°C in vapour compression cooling. The weight losses was increased with increasing storage time and the value of losses differ with difference storage systems, in Nawalla storage system the weight losses is higher than cold storage system. **Chourasia and Goswami (2007)** indicated that storage loss beyond permissible limits is one of the major problems in the potato cold storage industry. The existing stack dimensions and arrangement of the stacks within the cold store is one of the reasons behind these storage losses. On the other hand, the volume and height of the stack showed just the reverse effect. The width of the stack did not make any significant change in terms of temperature of the product which increased slightly with increases in the width. **Chourasia and Goswami (2008)** reported that product-cooling load is one of the most important components, contributing about two-thirds toward the total refrigeration load during the transient cooling period of a cold storage. *So the main objective of this research were evaluated the changes in potato quality as function of storage temperature and time*.

## MATERAILS AND METHODES

Data collected during summer seasons 2008-2009 at Denosher village- El Mehalla EL Kobra-Gharbia Governorate. Potato "Spunta variety" is stored in diffusion absorption refrigeration system. A samples was taken for determining the dimensions and then the coefficient of spherical shape. Size of each potato tuber was determined by measuring the main three axis of tuber; the major axis as tuber length (L), the intermediate diameter as tuber width (D), and the thickness of tuber (T) in millimeters using a vernier caliber with an accuracy of 0.1 mm. The sugar concentration in tuber during potatoes storage was measured by using a refractmeter (with accuracy 0.5 Prix No.). A pentrometer used to measure a firmness of potato tubers with accuracy 1 $kg/cm^2$ and $1b/in^2$. The weight of each tuber was determined using an electronic digital balance having a sensitivity of 5 g.

Table 1: The potato spunta tubers characteristics

| Characteristics | Spunta tuber | Characteristics | Spunta tuber |
|---|---|---|---|
| Average weight | 130±81 g | Width | 47-76 mm |
| Specific gravity | 1.0723 | Length | 77- 165 mm |
| Sugar | 15 Prix | Thickness | 35-58 mm |
| Shape index | 2.10 ±0.50 | Notes | Large tubers |

1. **Coefficient of spherical shape** of the measured samples was calculated according to (Ismail, 1988) as follows:

$$I = \frac{L}{\sqrt{DT}} \quad \text{, decimal}$$

Where: I = Coefficient of spherical shape; L = Length of tuber, mm; D = Width of tuber, mm. T = Thickness of potato tuber, mm.

**2. The theoretical** volumes calculated by the following equation (Mohsenin, 1986):

$$V_{theo.} = (\pi/6)\ (L*D*T) \quad \text{, } mm^3$$

**3. Specific gravity**: Measuring specific gravity of potato tuber was used a simple technique which applies to large objects such as fruit and vegetables is the specific gravity, the potato tuber is firstly weighted on the balance scale in air and then forced into the water and attached to by third. The second reading of the balance was taken after the tuber submerged completely in water. The two readings were used in the following expression to calculate specific gravity (SG): (Mohsenin, 1986)

**(SG)= Weight in air (g) / [Weight in air (g) – Weight in water (g)] $(SG)_L$**

Where: $(SG)_L$ is the specific gravity of water (equal one).

**Potato storage conditions.**

When entering potato crop inside refrigerator store, it should be subjected to lower temperature gradually for two weeks. After then fixed temperature between 4 to 10 °C from third week until it reach to export out storage. When extracting potato crop outside refrigerator, it should be subjected to higher temperature gradually for two to three weeks. This controlling of inside temperature refrigeration unit is required to keep potato characteristics, because potato subjected to lower or higher temperature suddenly destroyed the potato properties. Figure (1) describes the relationship between inside air temperature in refrigerator unit and outside air temperature around refrigerator unit. when entering potato crop in refrigeration unit the temperature was 14 and 12 °C during first and second week. By controlling of temperature gradually until it lowered to 4°C during fourth and fifth week. Before extracting potato crop, it should be increasing temperature gradually until it raised above 10°C. The average inside temperature in refrigeration unit was 10.21°C when the average outside temperature and temperature difference was 29.26 and 19.05 °C during storage period ( two months). Potato storage subjected to the maximum average outside temperature was 30.7 °C this gave a 12 and 10.5 °C of the average inside refrigeration unit. Also, the maximum average temperature difference (cooling effect) 18.7 and 20.1 °C. The minimum average temperature inside refrigeration unit was 4 °C under 29.5 and 31.9 °C, 25.5 and 27.9 °C of average outside temperature and cooling effect, respectively.

## RESULTS AND DISCUSSION

The potato stored characteristics in absorption refrigeration unit are affected by refrigeration conditions. The potato stored characteristics include: physical, chemical and mechanical properties; discussed as follows:

**Effect of cooling storage period on physical characteristics of potato tubers**

Determinations of the main dimensions of potatoes are very important for describing their technological characteristics in many respects. The measured dimensions of potato tubers include: length (L), width (W), and thickness (T) as measured for fresh potato (before storage) and stored potato (after storage).

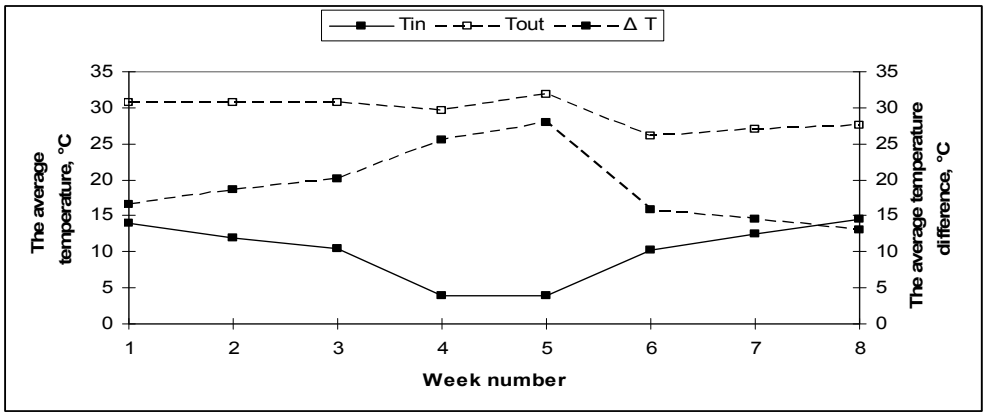



Fig. 1: The average, ambient air temperature, temperature difference and inside air temperature during storage period (two months).

Table (2): Statistical index of some physical properties for the investigated of fresh and stored potato tubers.

| Properties | Potatoes | Average $\bar{X}$ | Range Max-Min | S.D. ($\sigma_n$-1) | S.E. ($S_{\bar{X}}$) | C.V. % |
|---|---|---|---|---|---|---|
| Tuber Length, mm | Fresh | 114 | 165-77 | 22.37 | 3.72 | 19.62 |
| | Stored | 107.85 | 152-67 | 21.69 | 3.61 | 20.11 |
| Tuber Width, mm | Fresh | 60.08 | 76-47 | 7.53 | 1.25 | 12.25 |
| | Stored | 54.08 | 70-40 | 7.80 | 1.30 | 14.40 |
| Tuber Thickness, mm | Fresh | 46.58 | 58-35 | 5.30 | 0.88 | 11.39 |
| | Stored | 41.29 | 53-33 | 5.33 | 0.88 | 12.83 |
| Coefficient of Spherical shape | Fresh | 2.17 | 3.77-1.53 | 0.46 | 0.07 | 21.1 |
| | Stored | 1.89 | 2.68-1.35 | 0.37 | 0.06 | 19.57 |
| Potato tuber Weight, g | Fresh | 239.35 | 420-98 | 83.61 | 13.93 | 34.93 |
| | Stored | 224.26 | 390-85 | 77.77 | 12.96 | 34.67 |
| Calculated volume, $cm^3$ | Fresh | 170.21 | 292.09-68.18 | 55.12 | 9.18 | 32.38 |
| | Stored | 130.21 | 229.14-47.68 | 49.48 | 8.24 | 38 |

Typical mean values, obtained from large number of observations for the investigated potato before and after storage, are given in Table (2), with the arithmetic means of all samples, range of values, and other statistical indices for the main dimensions of the studied varieties, such as standard deviation ($\sigma_n$ -1), standard error (S.E), and coefficient of variance (C.V., %) to show the dispersion of the measured values around the mean.

For the sake of clarity, the results of physical properties of the two different investigated conditions of potato tubers which were measured or calculated,

statistically analyzed, represented graphically either in a variation frequency distribution curves or plotted in a histogram of the mean values, are discussed as follows:

**Frequency distribution of dimensions of potato tubers:**

**a- Potato tuber length:**

Figure (2a) indicates the frequency distribution curve and mean values for fresh and stored tubers length. The figure shows that the frequency distribution for the length of fresh potato was 0% of tubers< 65mm, 2.94% of tubers ranged from 65 to 75 mm, 11.76% of tubers ranged from 75 to 85mm, 26.47% of tubers ranged from 85 to 95 mm, 20.38% of tubers ranged from 95 to 105 mm, 2.94% of tubers ranged from 105 to 115 mm, 8.82% of tubers ranged from 115 to 125 mm, 17.64% ranged from 125 to 135mm, 2.94% of tubers ranged from 135 to 165mm. The corresponded frequency distribution for the length of stored potato was 2.94% of tubers < 75 mm, 11.76% of tubers ranged from 75 to 85 mm, 20.58% of tubers ranged from 85 to 95 mm, 20.58% of tubers ranged from 95 to 105 mm, 11.76% of tubers ranged from 105 to 115 mm, 2.94% of tubers ranged from 115 to 125mm, 14.70% of tubers ranged from 125 to 135mm, 11.76% of tubers ranged from 135 to 145 mm, 2.94% of tubers ranged from 145 to 155 mm and 0% of tubers < 165 mm. Linear regression analysis was applied to the data of potato tubers length after and before storage in absorption refrigerator unit (Figure 3a). The equation with the best fit was as follow:

$$Y = bX$$

Where: Y is length after storage, mm

X is length before storage, mm; and

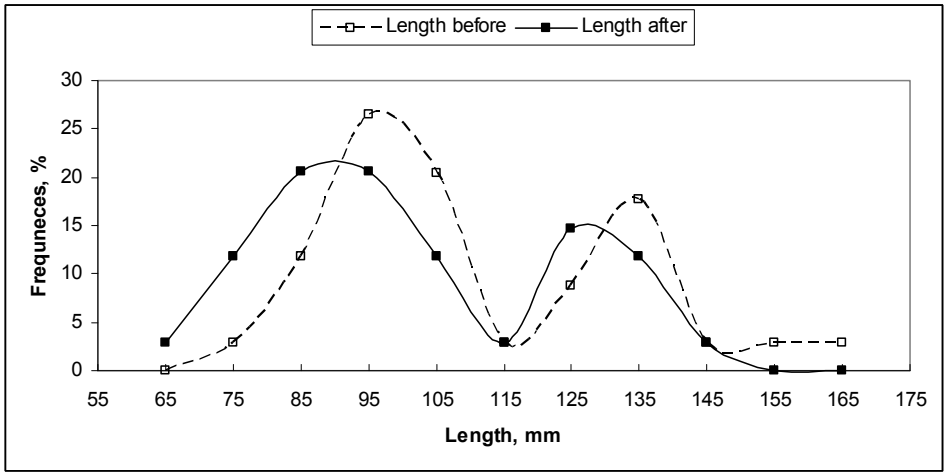
b is the slope of straight line

The slope of straight line was as follows:

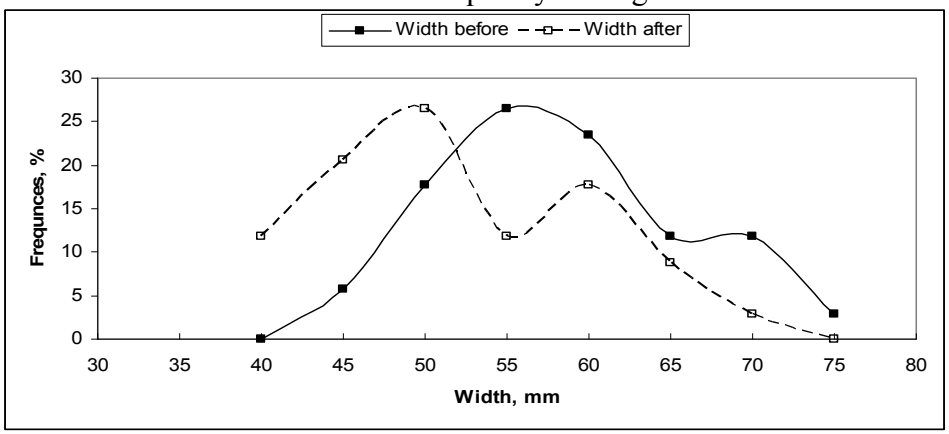
$L_{before\ storage} = 0.9638 L_{before\ storage}$, $R^2 = 0.9764$

**b- Potato tubers width:**

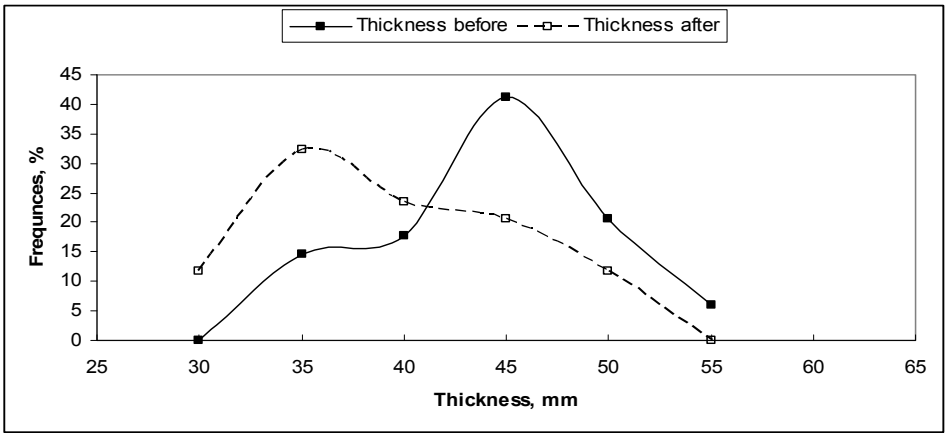
Figure (2b) indicates the frequency distribution curve and mean values of fresh potato tubers width (fresh and stored). The figure show that the frequency distribution for the width of fresh potato tubers was 0% < 45mm, 5.80% of tubers ranged from 45 to 50mm, 17.64% of tubers ranged from 50 to 55mm, 26.47% of tubers ranged from 55 to 60mm, 23.52% of tubers ranged from 60 to 65mm, 11.76% of tubers ranged from 65 to 75mm and 2.94% of tubers < 80mm.




a- Frequency of length

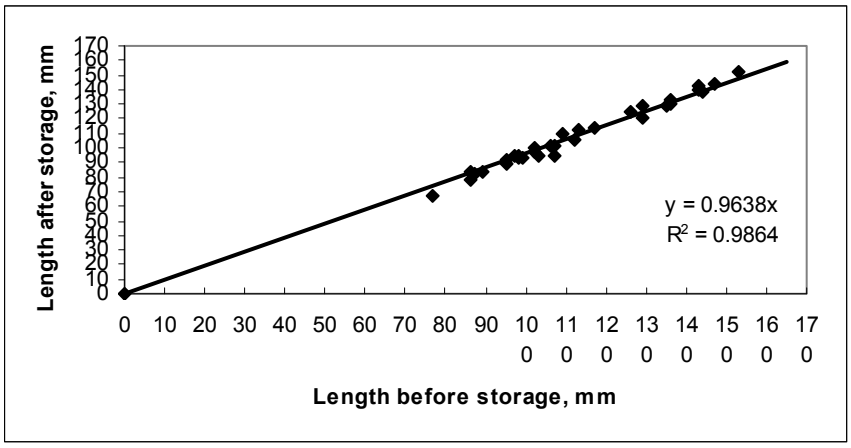



b- Frequency of width

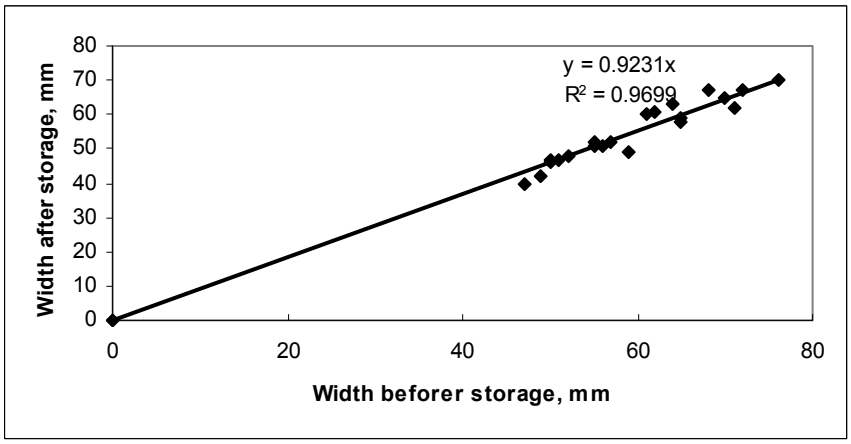



c- Frequency of thickness

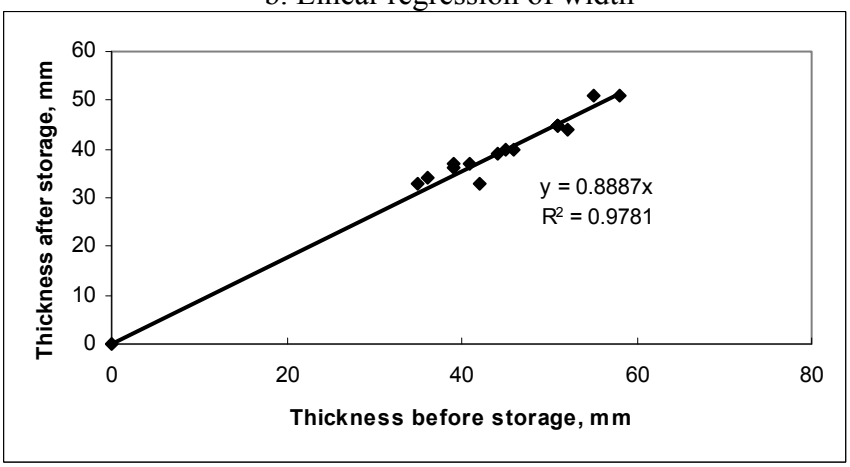
Fig. : 2. (a,b,c): Frequency distribution curves of dimensions for the investigated fresh and stored potato tubers.




a. Linear regression of length




b. Linear regression of width




c. Linear regression of thickness

Fig. 3: (, a, b, c): Linear regression of dimensions before and after storage.

The corresponding frequency distribution for fresh potato tubers width of stored potato tubers was 11.76% <45mm, 20.58% of tubers ranged from 45 to 50mm, 26.47% of tubers ranged from 50 to 55mm, 11.76% of tubers ranged from 55 to 60mm, 17.64% of tubers ranged from 60 to 65mm, 8.82% of tubers ranged from 65 to 70mm, 2.94% of tubers ranged from 70 to 75mm and 0% of tubers < 80mm.

Linear regression analysis was applied to the data of fresh and stored of potato tubers width in absorption refrigeration unit (Figure 3b). The equation with the best fit was as follow:

$W_{before\ after} = 0.9231 W_{before\ storage}$, $R^2 = 0.9135$

**c-<u>Potato tubers thickness</u>**

Distribution for the thickness of fresh was 0% of tubers < 35mm, 14.70% of tubers ranged from 35 to 40mm, 17.64% of tubers ranged from 40 to45mm, 41.17% of tubers ranged from 45 to 50mm, 20.58% of tubers ranged from 50 to 55mm and 5.88% of tubers ≤ 55mm. The corresponded frequency distribution for the thickness Linear regression of length of stored was 11.76% of tubers < 35mm, 32.35% of tubers ranged from 35 to 40mm, 23.52% of tubers ranged from 40 to 45mm, 20.58% of tubers ranged from 45 to 50mm, 11.76% of tubers ranged from 50 to 55mm and 0% of tubers <55mm. Linear regression analysis was applied to the data of fresh and stored of potato tubers thickness in absorption refrigerator unit (Figure 3c). The equation with the best fit was as follow:

$T_{after\ storage} = 0.8887_{before\ storage}$, $R^2 = 0.9097$

**d- <u>Coefficient of spherical shape:</u>**

The results in Figure (4) shows that fresh and stored potato tubers plotted through the coefficient from 1.4 to 3. Most fresh and stored potato tubers take oval shapes which have a coefficient of spherecity > 1.5. Meanwhile 2.94% and 20.58 % of fresh and stored potato tubers take a spherical shape, which have a coefficient of spherical shape ≤ 1.5.The obtained values of C.V., % for potato coefficient of spherical shape were (21.10 and 19.57%) for fresh and stored potato tubers, respectively.

**Weight of potato tuber**

Fresh and stored potato tubers weight was measured, statistically analyzed, and results of frequency distribution are shown in Figure (5). The figure

shows that the frequency distribution for the mass of fresh potato was 2.94% of tubers < 100 g, 5.88% of the tubers ranged from 100 to 150 g, 29.41% of

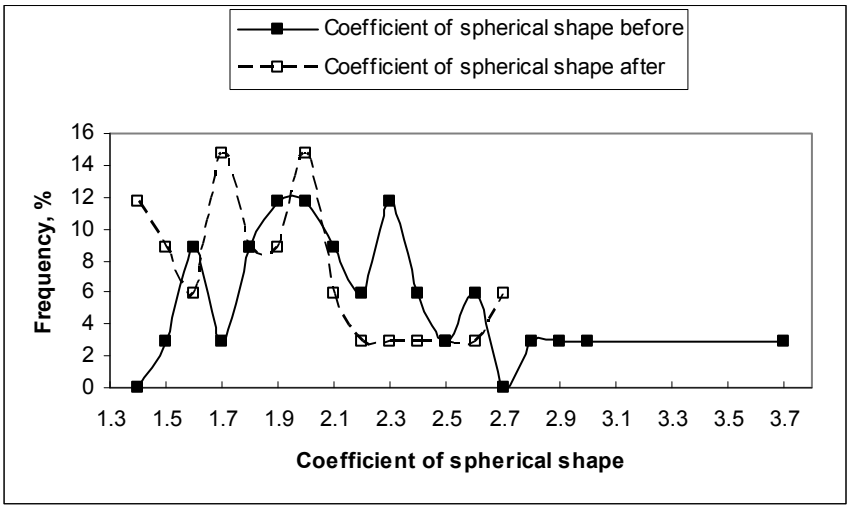



Fig 4: Frequency distribution curves of coefficient of spherical shape for the investigated fresh and stored potato.

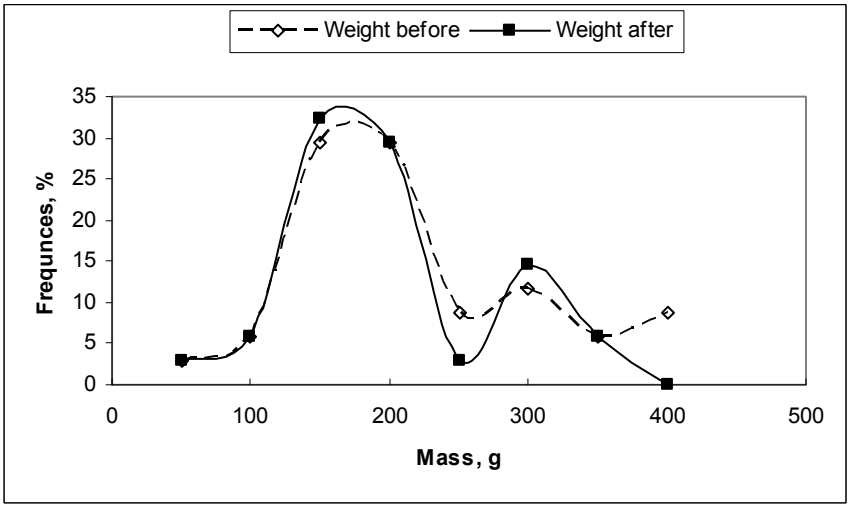



Fig. 5: Frequency distribution curves of weight for the investigated fresh and stored potato tubers.

the tubers ranged from 150 to 250 g, 8.79% of the tubers ranged from 250 to 300g, 11.76% of the tubers ranged from 300 to 350g, 5.88% of the tubers ranged from 350 to 400g and 8.82% of the tubers < 450g.

The corresponding frequency distribution for the mass of stored potato was 2.94% < 100g, 5.88% of the tubers ranged from 100 to 150g, 32.35% of the

tubers ranged from 150 to 200g, 29.41% of the tubers ranging from 200 to 250g, 2.94% of the tubers ranged from 250 to 300g, 14.70% of the tubers ranged from 300 to 350g, 5.88% of the tubers ranged from 350 to 400g and 0% of the tubers < 450g.

The statistical analysis showed that the C. V. was 34.93 and 34.67% for fresh and stored potato, respectively. Multiple regression equations were determined to describe the relationship between potato mass and its main dimensions for the fresh and stored potato tubers (Figure 6). The equations with the best fit as follows:

Fresh potato $W = 3.37 L + 0.53 W + 6.17 T$, $R^2 = 0.926$

Stored potato $W = 2.49 L + 2.73 W + 2.54 T$, $R^2 = 0.923$

It could be concluded that the dimensions (mm) of the fresh and stored potato tubers were directly proportional with its weight for both fresh and stored tubers.

**Specific gravity of potato tuber**

Specific gravity is the one of the physical properties. Specific gravity was investigated fresh and stored potato. The obtained mean values of fresh and stored potato tubers were (1.047 and 1.028), respectively. The maximum value of specific gravity was 1.088 and 1.062 for fresh and stored potato tubers, respectively. The minimum value of specific gravity was 1.012 and 0.998 for fresh and stored potato tubers, respectively. The previous result indicated that the specific weight for potato stored was less than fresh potato.

**Mechanical characteristics of potato tubers**

The obtained mean firmness of fresh and stored potato tubers were 0.64 and 0.56, respectively. The maximum and minimum fresh and stored potato firmness were (0.6 to 0.7) and (0.3 to 0.7), respectively. This means that the firmness of potato stored is less than fresh potato.

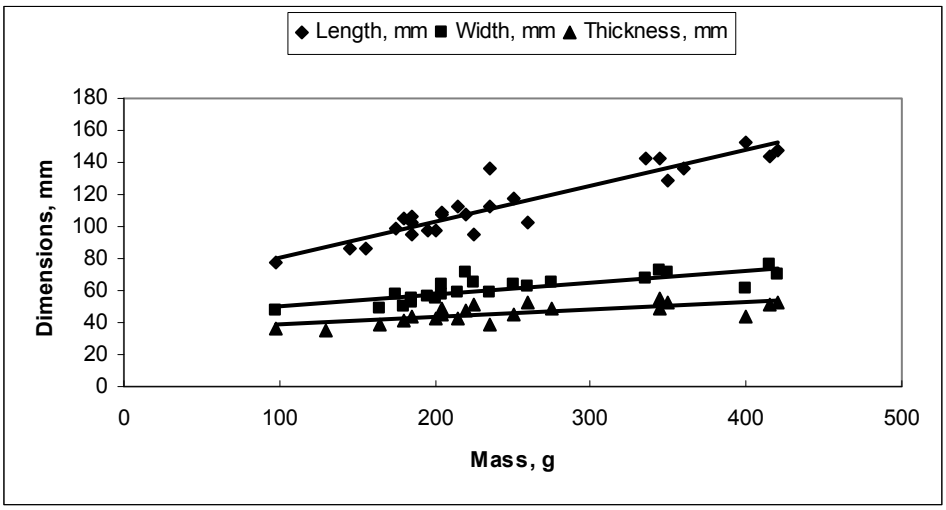
**Chemical characteristics of potato tubers**

The results of the sugar concentration (S.C, Prix) ranged from 5 to 6 Prix before storage . Meanwhile, This values ranged from 6.5 to 7 Prix

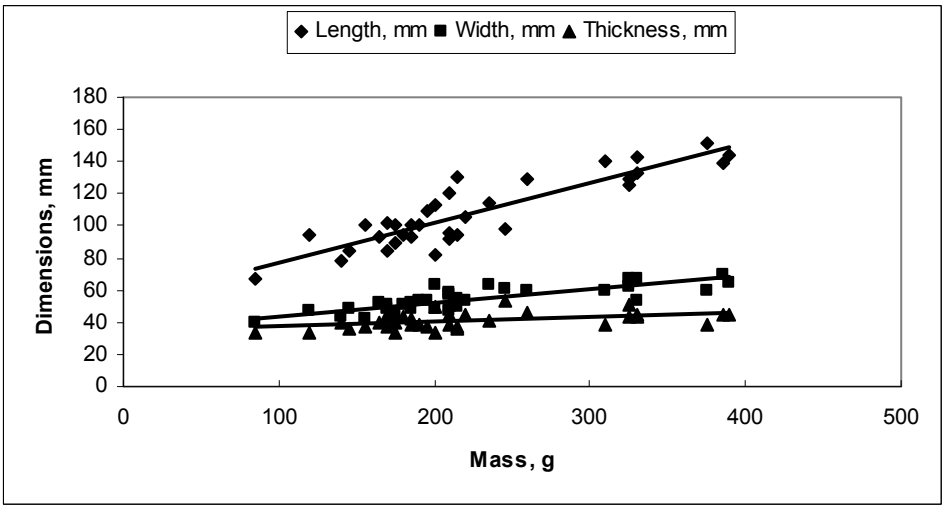
**Storage losses**

The storage evaluation depends upon the change of potato tubers characteristics after storage and the number of potatoes lost by infection and sprouts. The change of dimensions after storage process as a reduction was 5.21, 10, 11.19, and 12.76% for length, width, thickness and coefficient of spherical shape, respectively. Also, the reduction rate of weight was 9.2%

after storage process. The potato subjected to infection was 5.88% of stored potato tubers. The potato tubers which had sprouts were 11.76%. The number of sprouts ranged from 6 to 8 in absorption refrigerator unit. The best potato tuber was 82.35% of potato tubers. after storage. This means that the sugar concentration of stored potato is higher than the fresh potato.




a. Fresh potato




b. Stored potato

Fig. 6: Relationship between weight and dimensions for fresh and stored potato tubers.

## CONCLUSION

The mean values of potato length varied (from 77 to 165 mm) before storage, While it ranged (from 67 to 152 mm ) after storage . And decreasing rate of length was 5.21%.The mean values of potato width varied (from 47 to 76 mm) before storage, while it ranged (from 40 to 70 mm) after storage and decreasing rate of width was 10%.

The mean values of potato thickness varied(from 35 to 58 mm) before storage, while it ranged (from 33 to 53 mm) after storage and decreasing rate of thickness was 11.19%.

The coefficient of spherical shape of potato varied (from 1.53 to 3.77) before storage, while it ranged (from 1.35 to 2.68) after storage.

The mean values of potato weight varied (from 98 to 420 g) before storage, while it ranged (from 85 to 390 g) after storage.

The mean values of firmness of potato tuber ranged from (0.6 to 0.7 $N/mm^2$) before storage and it ranged (from 0.3 to 0.7 $N/mm^2$) after storage.

The mean values of sugar concentration of potato tube range (from 15 to 16.04, Prix) and it varied( from 16.5 to 17.5 Prix ).

The infected potato was 5.88%, the potato which had a sprouts was 11.76% and the potato good healthy was 82.35%.

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**الملخص العربى**

## تأثير التيريد بالامتصاص على مواصفات البطاطس

**د.محمد درويش د.عادل هلال د. اسعد دربالة ا.د طارق فودة وا.د محمد مراد**

تم تخزين محصول البطاطس (صنف إسبونتا) في كابينة التبريد بالامتصاص العاملة علي الطاقة الشمسية خلال فترة الصيف في الفترة من شهر مايو إلي شهر سبتمبر بحجم 1م$^3$ واستوعبت 200كجم . تم تشغيل نظام التسخين الشمسي من الساعة التاسعة صباحا و حتي الرابعة مساء حيث تراوحت درجة الحرارة داخل الكابينة خلال ساعات التشغيل نهارا ما بين 4 إلي 10 °م وهو المدي المناسب لتخزين البطاطس

تم قياس الخواص الطبيعية للبطاطس مثل الأبعاد (الطول- العرض- السمك) و كذا معامل التكور و الوزن والوزن النوعي وبعض الخواص الميكانيكية مثل الصلابة وبعض الخواص الكيميائية مثل تركيز السكريات . وكانت اهم النتائج المتحصل عليهاعند استخدام نظام التبريد بالامتصاص لتخزين محصول البطاطس هى:

1- وكان معدل التناقص الناتج من زمن التخزين في الطول و العرض والسمك 5.21 و.10 .و11.19%. على التوالى

**1،2 مدرس الهندسة الزراعية – قسم الهندسة الزراعية – كلية الزراعة – جامعة طنطا**
**3 أستاذ الهندسة الزراعية المساعد – قسم الهندسة الزراعية – كلية الزراعة – جامعة طنطا**
**4 أستاذ الهندسة الزراعية – كلية الزراعة – جامعة طنطا**
**5 أستاذ الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق**

2- تراوح معامل التكور لدرنات البطاطس من (1.53 إلي 3.77 ) قبل التخزين و من (1.35 إلي 2.68) بعد التخزين ، وكان معامل التناقص في معامل التكور 12.96%.

3- تراوح وزن درنة البطاطس من (98 إلي 420 جم ) قبل التخزين و من ( 85 إلي 390 جم ) بعد التخزين، وكان معامل التناقص في وزن الدرنات 9.2% .

4- تراوح الوزن النوعي لدرنات البطاطس من (1.012 إلي 1.088) قبل التخزين و من (0.998 إلي 1.062) بعد التخزين.

5- تراوحت الصلابة لدرنات البطاطس من (0.6 إلي 0.7 نيوتن / مم$^2$) قبل التخزين و من (0.3 إلي 0.7 نيوتن / مم$^2$) بعد التخزين.

6- تراوح تركيز السكريات من (15إلي 16.04 بركس) قبل التخزين و من (16.5 إلي 17.5 بركس ) بعد التخزين.

7- نسبة البطاطس المصابة 5.88% والبطاطس المتبرعمة 11.76% و نسبة البطاطس السليمة 82.35 %.

8- بلغت نسبة التوافق بين الوزن و الأبعاد 0.926 قبل التخزين و 0.923 بعد التخزين.