

## SOME PHYSICAL, MECHANICAL AND CHEMICAL PROPERTIES OF POTATO TUBERS (SPUNTA VARIETY)

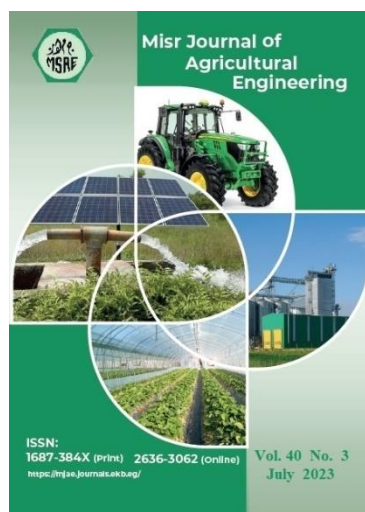
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### Keywords:

Potato tubers; Physical properties; Chemical properties; Dimensions; Surface area; Volume; Density; TSS.

### ABSTRACT

*The main aim of this work was to study the physical, mechanical and chemical properties of potato tubers (Spunta variety), to help in designing and developing of specific machine and their operations. The length, width and thickness of potato tubers values ranged from 60.03 to 89.93, 44.67 to 60.02 and 37.69 to 44.64 mm, respectively for all treatments under study. The geometric mean diameter and arithmetic mean diameter of the potato tubers ranged from 46.41 to 61.97 and 47.96 to 64.86 mm, respectively. The potato tuber mass was 63.72, 119.51 and 152.07 g for small, medium and large of potato tuber size, respectively. The potato tuber volume was 53.54, 112.96 and 135.12 cm<sup>3</sup> for small, medium and large of potato tuber size, respectively. The true density of the potato tuber ranged from 1190 to 1125 kg m<sup>-3</sup> for all treatments under study. The potato tubers surface area was 67.61, 104.68 and 120.58 cm<sup>2</sup> for small, medium and large of potato tuber size, respectively. The sphericity and moisture content potato tuber were 77.30, 75.02 and 68.91 and 83.64, 80.83 and 83.19 % for small, medium and large of potato tuber size, respectively. Total soluble solids, firmness, lightness and repose angle of potato tubers ranged from 4.43 to 4.65, 5.40 to 5.70, 69.93 to 73.22% and 30.61 to 33.04°. The total sugar and reducing sugar of potato tubers were 2.76, 2.30 and 2.55 and 0.49, 0.43 and 0.45 % for small, medium and large of potato tuber size, respectively.*

### 1. INTRODUCTION

Potato is one of the most important vegetable crops grown in all countries. In Egypt, potato is a major export crop. The total cultivated area of potato is about 432832 feddan (180346.7 ha). This area produced about 5.08 million Mg in 2019 according to CAPMS (2019). Physical characteristics of agricultural products are the most important parameters for the designing of grading, conveying, processing, and packaging systems. Among these physical characteristics, mass, volume, projected area, and center of gravity are the most important in sizing systems (Malcolm *et al.* 1986). Other important parameters are

width, length, and thickness (**Mohsenin 1986**). The frictional properties (angles of repose and coefficients of friction) are important in designing equipment and machines for harvesting, conveying, separating, sorting, handling, processing, storage, etc. The coefficient of static friction is used to determine the angle at which chutes must be positioned in order to achieve consistent flow of material through the chute. In addition, this coefficient is important in the designing of conveyors because friction is necessary to hold the potato tuber to the conveying surface without slipping or sliding backward (**Razavi et al. 2007 and Dalvand 2011**). Knowledge of dimensions, volume, surface area and mass of the product is necessary to: (a) the design of sorting and grading machines (b) predicting amounts of surface applied chemicals and (c) describing heat and mass transfer during thermal processes and in quantification of bruise, abrasion and damage in handling process. The shape of some fruits is important in determining their suitability for processing as well as their retail value. Many researches have been carried out on the physical and engineering properties of many agricultural products (**Khater and Bahnasawy, 2016**). The physical and mechanical properties such as size, friction angle, angle of repose, crushing strength and bulk density are important in the design of the handling system and grading (**Chandrasekar and Viswanathan, 1999**).

A study of the physical properties of biomaterials is essential for the design of processing machines, storage structures and environmental parameter controls. Such data are useful in the analysis and determination of the efficiency of a machine or an operation, development of new products and new equipment and final quality of new products (**Mohsenin, 1986**). The size of agricultural materials such as grains, pulses and oil seeds have been described by measuring their principal axial dimensions (**Oje et al., 2001 and Perez–Alegria et al., 2001**). Geometrical mean of the axial dimensions have also been shown to be adequate for calculating Reynold's number, projected areas and drag coefficient of food grain. These parameters are needed in the design of machine for pneumatic conveying, fluidization and separation of ground straw mixtures (**Gorial and O'Callaghan, 1990**). Density and specific gravity of biomaterials play important roles in many applications, and are useful in drying and storage of hay products, design of silos and storage bins (**Khater and Afify, 2021**).

Physical indices will help to determine the fruit optimal harvest time. These are: mass, size, shape, color, firmness, and number of days after flowering. Information on the fruit mechanical properties is also important to determine the fruit's degree of maturation. Consequently, compression tests may be employed to obtain force deflection curves to check fruit firmness (**Khater et al., 2014**).

The design of processing machines, storage structures and environmental parameter controls depend on the properties of bio-materials. These properties are useful in the analysis and determination of the efficiency of a machine or an operation, development of new products and new equipment and final quality of new products (**Mohsenin, 1986 and Khater and Bahnasawy, 2016**).

Export problems are mainly from the lack of physical and mechanical properties knowledge. Physical, mechanical and chemical properties are important in many problems associated with the design of machines and the analysis of the behaviour of the product during agricultural

processing operations such as handling, planting, harvesting, milling, threshing, cleaning, grading, sorting and drying, therefore, the main aim of this investigation is to study some physical, mechanical and chemical properties of the tubers of potato.

**2. MATERIALS AND METHODS**

The experiment was carried out at Agricultural and Bio-Systems Engineering Department, Faculty of Agriculture, Moshtohor, Benha University, during the period of March to July, 2021.

**2.1. Materials**

Potato (*Solanum tuberosum L.*) Spunta variety was brought from the local farms, at the beginning of the season. The potato was inspected and divided into three size categories, small, medium and large size for potato. The potato tubers (Spunta variety) were used in this study to measure and determine the physical and chemical properties.

**2.2. Methods**

**2.2.1. Physical properties**

**2.2.1.1. Dimensional characteristics**

For each potato tuber, three principle dimensions (axial dimension); length (L), width (W) and thickness (T) as shown in fig. (1) were measured using digital caliper (Model TESA 1p65-Range 0-150 mm ± 0.01 mm, Swiss) and the average was taken.

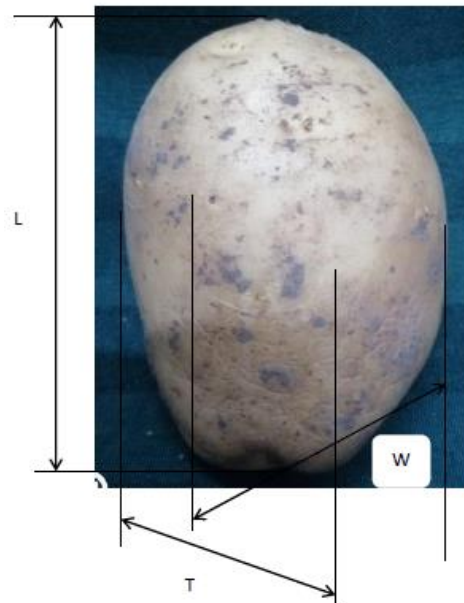


Fig. (1): Dimensions of potato tuber: length (L), width (W) and thickness (T)

**2.2.1.2. Geometric mean diameter**

The geometric mean diameter ( $D_g$ ) of samples was found using the following formula given by **Kacharu et al. (1994)**:

$$D_g = \sqrt[3]{LWT} \tag{1}$$

Where:

- $D_g$  is the geometric mean diameter, mm
- L is the length of potato tubers, mm
- W is the width of potato tubers, mm
- T is the thickness of potato tubers, mm

**2.2.1.3. Arithmetic mean diameter**

The arithmetic mean diameter was determined from the three principle diameter using the relationship by (Sunmonu *et al.*, 2015):

$$D_a = \frac{L + W + T}{3} \tag{2}$$

Where:

$D_a$  is the arithmetic mean diameter, mm

**2.2.1.4. Surface area**

The surface area was determined by using the following equation as cited by Sacilik *et al.*, (2003):

$$S = \pi(D_g)^2 \tag{3}$$

Where:

$S$  is the fruit surface area, mm<sup>2</sup>

**2.2.1.5. Sphericity**

The sphericity of the potato tuber was calculated by using the following relationship (Sunmonu *et al.*, 2015):

$$\phi = \frac{D_g}{L} \times 100 \tag{4}$$

Where:

$\phi$  is the fruit sphericity, %

**2.2.1.6. Mass and Real density of potato tuber**

The mass of potato tuber was measured by electric digital balance (Model Vibra – Range 0-12000 g ± 0.01 g, Japan). Water displacement method was used for determining the tubers measured volume ( $V_m$ ). The real density was a measurement of a potato tubers mass per unit volume. For each case, the determination was replicated three times and the mean was considered.

**2.2.1.7. Criteria projected area**

The criteria projected area (CPA) was calculated as suggested by Mohsenin (1986):

$$CPA = \frac{AP_1 + AP_2 + AP_3}{3} \tag{5}$$

Where:

$AP_1$  is the projected area perpendicular to L direction of fruit, mm<sup>2</sup>

$AP_2$  is the projected area perpendicular to T direction of fruit, mm<sup>2</sup>

$AP_3$  is the projected area perpendicular to W direction of fruit, mm<sup>2</sup>

Oblate spheroid ( $V_{osp}$ ) and ellipsoid ( $V_{ellip}$ ) shapes were calculated as:

$$V_{osp} = \frac{4\pi}{3} \left(\frac{L}{2}\right) \left(\frac{W}{2}\right)^2 \tag{6}$$

$$V_{ellip} = \frac{4\pi}{3} \left(\frac{L}{2}\right) \left(\frac{W}{2}\right) \left(\frac{T}{2}\right) \tag{7}$$

Where:

$V_{osp}$  is the oblate spheroid volume, mm<sup>3</sup>

$V_{ellip}$  is the ellipsoid shape volume, mm<sup>3</sup>

### 2.2.1.8. Moisture content

The moisture content of randomly selected potato tubers was determined according to **ASAE Standard (1984)**. Three samples of each potato tubers were randomly selected and weighed on an electric digital balance. Drying oven (Model 655F Cat. No. 13-245-655, range 50 to 300 °C, Canada) at 70°C until a constant weight was used to measure the moisture content.

### 2.2.2. Mechanical Properties:

#### 2.2.2.1. Repose angle of potato tubers

The angle of repose is the minimum angle at which any piled-up bulky or loose material will stand without falling downhill. It is the angle between the horizontal base and inclined side of the formed cone due to free fall of potato tubers sample.

#### 2.2.2.2. Coefficient of friction

The coefficient of friction between potato tubers and a wall is the ratio of the normal force to the friction force along the wall surface. It is dependent on the tubers stored, and the type of surface (Galvanized steel, Plywood and Concrete) in contact with tubers (**ASAE, 1987 and Khater and Bahnasawy, 2018**).

### 2.2.3. Chemical properties:

#### 2.2.3.1. Total Soluble solids

The total soluble solids percent (TSS%) was measured by using a hand refractometer (ATAGO Co., LTD., Tokyo, Japan) and the result was expressed as a percentage (%).

#### 2.2.3.2. Total and reducing sugars

Total and reducing sugars were estimated calorimetrically using the Nelson arsenate–molybdate colorimetric method (**Nielsen, 2010**). Non-reducing sugars were measured by the difference between total sugars and reducing sugars.

#### 2.2.3.3. Total firmness

A Magness and Taylor pressure tester measured tuber firmness (%) with a 7/18-inch plunger. Lightness potato color was measured by using a Minolta Chroma meter (Model CR 300, Japan).

## 3. RESULTS AND DISCUSSIONS

### 3.1. Physical properties

Table (1) shows the dimensions (length, width and thickness) of potato tubers, geometric mean diameter and arithmetic mean diameters of the potato tubers for different potato sizes. The results showed that the length of potato tubers value were  $60.03 \pm 3.48$ ,  $76.96 \pm 4.05$  and  $89.93 \pm 3.29$  mm for small, medium and large of potato tuber size, respectively. The width of potato tubers value were  $44.67 \pm 2.71$ ,  $56.78 \pm 2.19$  and  $60.02 \pm 2.81$  mm for small, medium and large of potato tuber size, respectively. Also, the thickness of potato tubers value were  $37.69 \pm 1.99$ ,  $44.59 \pm 2.31$  and  $44.64 \pm 1.87$  mm for small, medium and large of potato tuber size, respectively. These dimension data are very important in handling, packing and storage capacity determination. These results are in agreement with **Gomea et al. (2009)**.

The results also indicate that, the geometric mean diameter and arithmetic mean diameter of the potato tubers were  $46.41 \pm 2.61$ ,  $57.74 \pm 2.18$  and  $61.97 \pm 2.93$  and  $47.96 \pm 2.70$ ,  $59.44 \pm 2.09$  and  $64.86 \pm 2.82$  mm, respectively, for small, medium and large of potato tuber size.

Table (1): Dimensional characteristic of potato tubers for different potato sizes.

| Properties                    | Potato Tuber Size |            |            |
|-------------------------------|-------------------|------------|------------|
|                               | Small             | Medium     | Large      |
| Length (mm)                   | 60.03±3.48        | 76.96±4.05 | 89.93±3.29 |
| Width (mm)                    | 44.67±2.71        | 56.78±2.19 | 60.02±2.81 |
| Thickness (mm)                | 37.69±1.99        | 44.59±2.31 | 44.64±1.87 |
| Geometric mean diameter (mm)  | 46.41±2.61        | 57.74±2.18 | 61.97±2.93 |
| Arithmetic mean diameter (mm) | 47.46±2.70        | 59.44±2.09 | 64.86±2.82 |

Table (2) shows the tuber mass, volume, true density, surface area, sphericity and moisture content of the potato tubers for different sizes. The results showed that the potato tuber mass were  $63.72 \pm 4.22$ ,  $119.51 \pm 3.89$  and  $152.07 \pm 4.01$  g for small, medium and large of potato tuber size, respectively. The volume of tubers was  $53.54 \pm 5.70$ ,  $112.96 \pm 8.92$  and  $135.12 \pm 4.33$  cm<sup>3</sup> for small, medium and large of potato tuber size, respectively. The true density of the potato tuber was  $1190 \pm 12.66$ ,  $1058 \pm 9.42$  and  $1125 \pm 10.07$  kg m<sup>-3</sup> for small, medium and large of potato tuber size, respectively. The potato tubers surface area was  $67.61 \pm 5.05$ ,  $104.68 \pm 4.27$  and  $120.58 \pm 4.93$  cm<sup>2</sup> for small, medium and large of potato tuber size, respectively.

Table (2): Mass, volume, true density, surface area, sphericity and moisture content of potato tubers for different potato sizes.

| Properties                         | Potato Tuber Size |             |             |
|------------------------------------|-------------------|-------------|-------------|
|                                    | Small             | Medium      | Large       |
| mass (g)                           | 63.72±4.22        | 119.51±3.89 | 152.07±4.01 |
| Volume (cm <sup>3</sup> )          | 53.54±5.70        | 112.96±8.92 | 135.12±4.33 |
| True density (kg m <sup>-3</sup> ) | 1190±12.66        | 1058±9.42   | 1125±10.07  |
| Surface area (cm <sup>2</sup> )    | 67.61±5.05        | 104.68±4.27 | 120.58±4.93 |
| Sphericity (%)                     | 77.30±4.94        | 75.02±5.13  | 68.91±3.62  |
| Moisture content (% , w.b)         | 83.64±3.97        | 80.83±2.81  | 83.19±3.06  |

The sphericity potato tuber was  $77.30 \pm 4.94$ ,  $75.02 \pm 5.13$  and  $68.91 \pm 3.62$  % for small, medium and large of potato tuber size, respectively. These results are in agreement with **Janatizadeh et al. (2008)**. The moisture content of potato tuber was  $83.64 \pm 3.97$ ,  $80.83 \pm 2.81$  and  $83.19 \pm 3.06$ % for small, medium and large of potato tuber size, respectively.

Table (3) shows the projected area, criteria projected area, oblate spheroid volume and ellipsoid shape volume of the potato tubers for different sizes. The results showed that the projected area perpendicular to L direction of potato tubers were  $26.82 \pm 1.69$ ,  $43.40 \pm 2.01$  and  $53.98 \pm 2.24$  cm<sup>2</sup> for small, medium and large of potato tuber size, respectively.

Table (3): AP1, AP2, AP3, CAP, V<sub>osp</sub> and V<sub>ellip</sub> of potato tubers for different potato sizes.

| Properties                            | Potato Tuber Size |             |             |
|---------------------------------------|-------------------|-------------|-------------|
|                                       | Small             | Medium      | Large       |
| AP1 (cm <sup>2</sup> )                | 26.82±1.69        | 43.40±2.01  | 53.98±2.24  |
| AP2 (cm <sup>2</sup> )                | 22.03±1.72        | 34.32±2.30  | 40.14±2.33  |
| AP3 (cm <sup>2</sup> )                | 16.84±1.55        | 25.32±2.17  | 26.79±1.99  |
| CAP (cm <sup>2</sup> )                | 22.09±1.73        | 34.44±2.35  | 40.30±3.06  |
| V <sub>osp</sub> (cm <sup>3</sup> )   | 62.79±3.55        | 129.85±4.91 | 169.54±4.58 |
| V <sub>ellip</sub> (cm <sup>3</sup> ) | 52.89±3.78        | 101.97±5.02 | 126.10±4.66 |

The projected area perpendicular to W direction of potato tubers were  $22.03 \pm 1.72$ ,  $34.32 \pm 2.30$  and  $40.14 \pm 2.33$  cm<sup>2</sup> for small, medium and large of potato tuber size, respectively, and the projected area perpendicular to T direction of potato tubers were  $16.84 \pm 1.55$ ,  $25.32 \pm 2.17$  and  $26.79 \pm 1.99$  cm<sup>2</sup> for small, medium and large of potato tuber size, respectively.

The oblate spheroid volume and ellipsoid shape volume of the potato tubers were  $62.79 \pm 3.55$ ,  $129.85 \pm 4.91$  and  $169.54 \pm 4.58$  and  $52.89 \pm 3.78$ ,  $101.97 \pm 5.02$  and  $126.10 \pm 4.66$ , respectively.

### 3.2. Mechanical properties:

Table (4) shows repose angle, firmness and coefficient of static friction of the potato tubers for different sizes. The results indicate that the repose angle increases with increasing the size of potato tubers. It could be seen that the repose angel of potato tubers was increased from  $30.61 \pm 2.40$  to  $33.04 \pm 2.88^\circ$ , when the size of potato tuber increased from small to large, respectively. The firmness of potato tubers were  $5.70 \pm 1.08$ ,  $5.40 \pm 0.91$  and  $5.70 \pm 0.83$  % for small, medium and large of potato tuber size, respectively. The results also indicate that the coefficient of static friction for the potato tubers increases with increased the size of potato tubers. It could be seen that the coefficient of static friction for the potato tubers was increased from  $0.43 \pm 0.07$  to  $0.61 \pm 0.10$ ,  $0.47 \pm 0.06$  to  $0.62 \pm 0.11$  and  $0.50 \pm 0.07$  to  $0.64 \pm 0.09$  when the size of potato tuber increased from small to large, respectively for galvanized steel, plywood and concrete surface.

Table (4): Some mechanical properties of potato tuber for different potato sizes.

| Properties                     |                  | Potato Tuber Size |                  |                  |
|--------------------------------|------------------|-------------------|------------------|------------------|
|                                |                  | Small             | Medium           | Large            |
| Repose angle, °                |                  | $30.61 \pm 2.40$  | $31.97 \pm 2.74$ | $33.04 \pm 2.88$ |
| Firmness, %                    |                  | $5.70 \pm 1.08$   | $5.40 \pm 0.91$  | $5.70 \pm 0.83$  |
| Coefficient of static friction | Galvanised steel | $0.43 \pm 0.07$   | $0.47 \pm 0.07$  | $0.61 \pm 0.10$  |
|                                | Plywood          | $0.47 \pm 0.06$   | $0.41 \pm 0.08$  | $0.62 \pm 0.11$  |
|                                | Concrete         | $0.50 \pm 0.07$   | $0.56 \pm 0.09$  | $0.64 \pm 0.09$  |

### 3.3. Chemical properties:

Table (5) shows total soluble solids, lightness, dry matter, total sugar, reducing sugar and non-reducing sugar of the potato tubers for different sizes. It could be seen that the total soluble solids (TSS) of potato tubers were  $4.65 \pm 0.55$ ,  $4.43 \pm 0.52$  and  $4.55 \pm 0.30$  % for small, medium and large of potato tuber size, respectively.

Table (5): Some chemical properties of potato tuber for different potato sizes.

| Properties                    |  | Potato Tuber Size |                  |                  |
|-------------------------------|--|-------------------|------------------|------------------|
|                               |  | Small             | Medium           | Large            |
| Total soluble solids (TSS), % |  | $4.65 \pm 0.55$   | $4.43 \pm 0.52$  | $4.55 \pm 0.30$  |
| Lightness, %                  |  | $69.93 \pm 4.55$  | $73.22 \pm 3.90$ | $72.99 \pm 4.01$ |
| Dry matter, %                 |  | $16.36 \pm 1.89$  | $19.17 \pm 2.02$ | $16.81 \pm 1.72$ |
| Total sugar, %                |  | $2.76 \pm 0.61$   | $2.30 \pm 0.74$  | $2.55 \pm 0.59$  |
| Reducing sugar, %             |  | $0.49 \pm 0.13$   | $0.43 \pm 0.09$  | $0.45 \pm 0.17$  |
| Non-Reducing sugar, %         |  | $2.27 \pm 0.44$   | $1.87 \pm 0.59$  | $2.10 \pm 0.60$  |

The lightness of potato tubers were  $69.93 \pm 4.55$ ,  $73.22 \pm 3.90$  and  $72.99 \pm 4.01$  % for small, medium and large of potato tuber size, respectively. The dry matter of potato tubers were

16.36 ± 1.89, 19.17 ± 2.02 and 16.81 ± 1.72 % for small, medium and large of potato tuber size, respectively. The total sugar of potato tubers were 2.76 ± 0.61, 2.30 ± 0.74 and 2.55 ± 0.59 % for small, medium and large of potato tuber size, respectively. These results are in agreement with **Piret *et al.* (2020)**.

The reducing sugar of potato tubers were 0.49 ± 0.13, 0.43 ± 0.09 and 0.45 ± 0.17 % for small, medium and large of potato tuber size, respectively. The non-reducing sugar of potato tubers were 2.27 ± 0.44, 1.87 ± 0.59 and 2.10 ± 0.60 % for small, medium and large of potato tuber size, respectively.

#### **4. CONCLUSIONS**

An experimental study was carried out successively to determine the physical and chemical properties of potato tubers. The obtained results can be summarized as follows:

The length, width and thickness of potato tubers values ranged from 60.03 to 89.93, 44.67 to 60.02 and 37.69 to 44.64 mm, respectively for all treatments under study. The geometric mean diameter and arithmetic mean diameter of the potato tubers ranged from 46.41 to 61.97 and 47.96 to 64.86 mm, respectively. The potato tuber mass was 63.72, 119.51 and 152.07 g for small, medium and large of potato tuber size, respectively. The potato tuber volume was 53.54, 112.96 and 135.12 cm<sup>3</sup> for small, medium and large of potato tuber size, respectively. The true density of the potato tuber ranged from 1190 to 1125 kg m<sup>-3</sup> for all treatments under study. The potato tubers surface area was 67.61, 104.68 and 120.58 cm<sup>2</sup> for small, medium and large of potato tuber size, respectively. The sphericity potato tuber was 77.30, 75.02 and 68.91 % for small, medium and large of potato tuber size, respectively. The moisture content of potato tuber was 83.64, 80.83 and 83.19 % for small, medium and large of potato tuber size, respectively. The repose angle for potato tubers was ranged from 30.61± 2.40 to 33.04±2.88°. The firmness of potato tubers ranged from 5.40 to 5.7 0 % for all treatments under study. TSS of potato tubers ranged from 4.43 to 4.65 %. The lightness of potato tubers ranged from 69.93 to 73.22 %. The dry matter of potato tubers were 16.36, 19.17 and 16.81 % for small, medium and large of potato tuber size, respectively. The total sugar of potato tubers were 2.76, 2.30 and 2.55 % for small, medium and large of potato tuber size, respectively. The reducing sugar of potato tubers were 0.49, 0.43 and 0.45 % for small, medium and large of potato tuber size, respectively.

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## بعض الخصائص الطبيعية والميكانيكية والكيميائية لدرنات البطاطس (صنف اسبونتأ)

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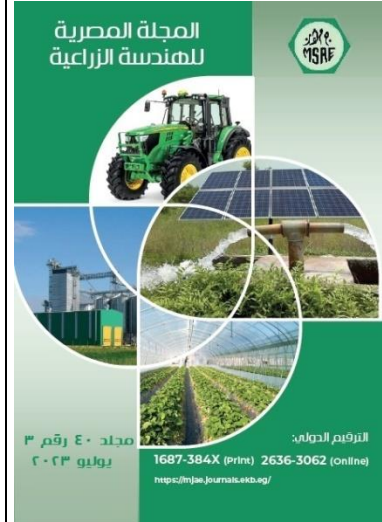
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### الملخص العربي

يهدف هذا البحث الى دراسة بعض الخصائص الطبيعية والميكانيكية والكيميائية لدرنات البطاطس (صنف اسبونتأ) لما تمثله هذه الخصائص من أهميه فى عملية التداول والتخزين ومعاملات ما بعد الحصاد كعمليات أوليه فى العمليات التصنيعية المختلفة، وبغرض المساهمة فى تقليل الأضرار الميكانيكية التى تتعرض لها الدرنات أثناء عمليات التداول والتخزين. وكان اهم النتائج هى: تراوح كلا من الطول والعرض والسك لدرنات البطاطس ما بين ٦٠,٠٣ الى ٨٩,٩٣ ومن ٤٤,٦٧ الى ٦٠,٠٢ ومن ٣٧,٦٩ الى ٤٤,٦٤ مم، على الترتيب لكل المعاملات تحت الدراسة. وتراوح كلا من متوسط القطر الهندسى ومتوسط القطر الحسابى لدرنات البطاطس من ٤٦,٤١ الى ٦١,٩٧ ومن ٤٧,٩٦ الى ٦٤,٨٦ مم، على الترتيب. كان الوزن الكلى لدرنات البطاطس هى ٦٣,٧٢ و ١١٩,٥١ و ١٥٢,٠٧ جم لكل من مقاس الدرنات الصغيرة والمتوسطة والكبيرة على الترتيب. وكان حجم درنات البطاطس هى ٥٣,٥٤ و ١١٢,٩٦ و ١٣٥,١٢ سم<sup>٣</sup> لكل من مقاس الدرنات الصغيرة والمتوسطة والكبيرة على الترتيب. تراوحت الكثافة الحقيقية لدرنات البطاطس ما بين ١١٩٠ الى ١١٢٥ كجم م<sup>-٣</sup> لكل المعاملات تحت الدراسة. كان متوسط المساحة السطحية لدرنات البطاطس هى ٦٧,٦١ و ١٠٤,٦٨ و ١٢٠,٥٨ سم<sup>٢</sup> لكل من مقاس الدرنات الصغيرة والمتوسطة والكبيرة على الترتيب. كان متوسط الكروية والمحتوى الرطوبى لدرنات البطاطس هو ٧٧,٣٠ و ٧٥,٠٢ و ٦٨,٩١ و ٨٣,٦٤ و ٨٠,٨٣ و ٨٣,١٩ % و ٧٦,٨٥ و ٨٦,٣٤ % على الترتيب، لكل من مقاس الدرنات الصغيرة والمتوسطة والكبيرة. تراوحت زاوية التكوين لدرنات البطاطس ما بين ٣٠,٦١ إلى ٣٣,٠٤. تراوحت المواد الصلبة الكلية الذائبة لدرنات البطاطس ما بين ٤,٤٣ الى ٤,٦٥ %. كان متوسط السكرية الكلية و ٢,٧٦ و ٢,٣٠ و ٢,٥٥ % والسكرية المختزلة ٠,٤٩ و ٠,٤٣ و ٠,٤٥ % والسكريات الغير مختزلة هى ٢,٢٧ و ١,٨٧ و ٢,١٠ % لكل من مقاس الدرنات الصغيرة والمتوسطة والكبيرة، على الترتيب.



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### الكلمات المفتاحية:

درنات البطاطس؛ الخصائص الطبيعية؛ الخصائص الميكانيكية؛ الخصائص الكيميائية؛ الأبعاد؛ المساحة السطحية؛ الحجم؛ الكثافة؛ المواد الصلبة الكلية الذائبة.