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TOMATO SORTING ACCORDING OPTICAL PROPERTIES FOR ITS MATURITY STAGES

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ABSTRACT

In the current paper, automatic control unit for tomato sorting according to their color based on using two control factors (feeding speed and sensor height) under steady air velocity with different performance evaluation parameters (sorting efficiency, productivity, energy requirement and operation cost with two varieties tomato (Bito 86 and Zaina Rs 692). The results showed that, the feeding speed at the range from 0.10 to 0.15 m/s gave the height value of sorting efficiency from 97.48 to 96.18% with productivity from 80.70 to 94.80bkg/h at sensor height of 35 mmm for Bito 86. Also, the height value of sorting efficiency from 96.74 to 96.38% with productivity from 57.90 to 67.80 kg/h respectively at sensor height of 30mm for Zaina Rs 692.Relating to the effect of feeding speed on energy requirement, the obtained data showed that, increasing feeding speed from 0.10 to 0.225 m/s, the energy requirement decreased from 3.83 to 3.97 and 5.35 to 4.25 kW.h/ton for Bito 86 and Zaina Rs 692 respectively. The operation cost of sorting machine depended mainly on the sorting productivity, required power and number of workers. Refering to the effect of the previous factors operation cost equal 5.66 L.E/h

INTRODUCTION

Sorting of agricultural products is accomplished based on appearance (color and absence defects), texture, shape and sizes. Manual sorting is based on traditional visual quality inspection performed by human operators, which is tedious, time-consuming, slow and non-consistent. It has become increasingly difficult to hire personnel who are adequately trained and willing to undertake the tedious task of inspection. A cost effective, consistent, superior speed and accurate

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sorting can be achieved with machine vision assisted sorting . Sorting is a separation based on a single measurable property of raw material units, while grading is "the assessment of the overall quality of a food using a number of attributes". Grading of fresh product may also be defined as 'sorting according to quality', as sorting usually upgrades the product (Brennan, 2006). **Kondo (2009)** reported that, roles of automated grading systems are as follows; 1) Efficient sorting and labor saving; 2) Uniformitarian of fruit quality, 3) Enhancing market value of products; 4) Fair payment to producers based not only on quantity but on quality of each product; 5) Farming guidance from grading results and GIS (Geographical Information System), and 6) Contribution to the traceability system for food safety and security. **Helmy (2002)** designed and constructed a photoelectric setup for sorting and grading of Egyptian oranges according to the reflection properties. The HE-Ne Laser was used as a light source in the machine. The optimum speed of machine belt and the mean capacity for orange varieties were found to be 0.47 m/s and 0.82 Mg/h, respectively. **Helmy et al. (2003)** classified fresh tomatoes into sixteen maturity grades namely green, spring green, light green, breaker, sand, light orange, peach, turning, color, faded pink, soft pink, pink, tropical pink, light red, neon red and red. They used a digital camera to take images for fresh tomato fruits sample; each fruit had two images, from up and down. The intensity of used light was 530 Lux., and they gave average of reflectance and RGB (Red, Green and Blue) values of the classified tomatoes. **El-Raie et al. (2003)** used in their experiments a random sample of fresh tomato (250 fruits). The optical properties of fruits at different wavelengths of visible Laser were taken. Two types of laser were used, the first one was Argon laser with two wavelengths 488 nm with incident light equals 4640 lux and 514 nm with incident light equals 4680 lux. The second laser was Helium-Neon with wavelength 632.8 nm with incident light equals 700 lux. **Sirisathitkul et al. (2006)** mentioned that, color grading is an important process for the agriculture industry especially in food processing, fruit and vegetable grading. The color of products is often used to determine quality and price. Consumers have developed distinct correlations between color and the overall quality of a specific product. **Zhang et al. (2011)** developed a robot for tomato sorting based on surface color features of tomatoes. First of all tomatoes were removed from feeding mechanism onto the conveyor belt and distributed in all channels and their position were adjusted freely. Subsequently the tomatoes were transported to testing scale. Once immature tomatoes and other foreign matters were identified from tomatoes by CCD cameras based on their surface color, they would be rejected immediately by drive mechanisms. **Hahn (2002)** proposed the use of machine vision to increase sorting accuracy. **El-Raie et al. (2005)** measured the electrical and optical properties of strawberry maturity stages, using He-Ne LASER with wavelengths 632.8 (Red) and 543.5 (Green) nm with low power. **Mostafa (2003)** developed an appropriate system for grading onion bulbs by size. His results showed that, the optimum operational conditions at 0.23 m/s and zero longitudinal angles achieved maximum grading efficiency of (94.9%) for Giza-20 onion variety. **Bahnasawy et al., (2004)** reported that, the knowledge of length, width, volume, surface area and weight of the product is necessary to: a) Design of sorting and grading machines and b) Predicting amounts of surface applied chemicals. **Onder Kabas et al.,** (2006) reported that, the physical properties is necessary for the design of equipment for harvesting, transporting, cleaning, sorting, packing, storing, processing etc.

The Objectives of the study is to

1. Sort tomato automatically as color beside that Studying some physical properties of tomato such as shape and size, length, width, thickness, mass, geometric mean diameter, aspect ratio, surface area, of the individual fruit. Two varieties of tomato crop were selected and tested, namely tomato (Bito86) and tomato (zaina Rs692).
2. Study the effect of different factors on tomato sorting (productivity, sorting efficiency, energy unit requirements and operational cost unit).

MATERIALS AND METHODS

General description of sorting prototype

The sorting prototype was designed, manufactured in the local workshop. These prototypes characterized by a simple design, most of its parts are locally available materials, low costs manufacture and ease of construction. The designed prototype consists of the following main parts:

1 - Frame; 2- Feeding unit; 3- Sensors unit; 4- Electrical control unit 5- Power unit, 6- Distributing unit; and 7- Air compressing unit

The Studied factors affected on tomato sorting

- Four feeding speed : (0.1, 0.15, 0.2 and 0.25 m/s)
- Four Sensor Height : (25, 30, 35 and 40 mm)
- Air velocity was constant at (10 m/s).
- Two types of tomato fruits,(Bito 86) and (Zaina Rs692)

The **Measurements were :-**

- Physical characteristics of crop
- Sorting Productivity (kg / h).
- Sorting Efficiency (%).
- Power (kW) and consumption energy (kW. H / kg).
- The Cost required for the process of sorting (L.E / h).

Some Measurements connected with crops

1 - Determination of fruit dimensions: The mean dimensions length (L), width (W), thickness (T) for each fruit estimated by digital fernier caliper with accuracy of 0.01 mm.

Geometric mean diameter of the measured samples was calculated according to (**Chakespari et al., 2010**) as follows:

$$D_g = \sqrt[3]{LWT} \quad \text{.................................(3-1)}$$

Where: Dg = geometric mean diameter, mm; L = Length of sample, mm; W = Width of sample, mm. and T = Thickness sample, mm.

3- Mass of fruit: The mass of tomato fruit was determined by using an electronic digital balance having a sensitivity of 0.01 g.

4 - The aspect ratio (Ra): used to express the shape of a fruit. It is calculated using the length (L) and the width (W) of the fruit as (Mohsenin, 1986):

$$Ra = \frac{W}{L} * 100 \quad \text{.....................................(3-2)}$$

Aspect ratio (Ra) was used to detect short, medium and tall fruits

2 - Determination of static and dynamic coefficient of friction

1. Static coefficient of friction

$$\mu = \tan \theta \quad \text{.. (3.3)}$$

Where: θ = The angle of tilt (degree); and

μ = static coefficient of friction.

2. Dynamic coefficient of friction

The dynamic coefficient of friction between fruit and surface plat was evaluated, using the following equation **(Abdel-Mageed and Abd-Alla 1994)**

$$\mu = \frac{F}{W} \quad \theta \text{ .... } (3.4)$$

Where: μ = coefficient of friction, dimensionless;

F = force which marks fruit to start moving on the horizontal plane. (N); and

m = mass of fruit. (N).

Some Measurements connected with the machine:

1- Rotational speed of the rotating shaft: This velocity was measured by means of a multi-range hand tachometer

2 - Electric power: A digital clamp meter and voltmeter were used for measuring current intensity and voltage respectively. Figure (3.14) represents on image of the used digital clamp meter device. **(Suliman and Abd El maksoud, 2001).**

The electric power (P, Watt) was calculated based on current intensity (I, Ampere) and the voltage (V, volt) measurements, by using Digital clamp meter for measuring current and voltage using the following formula:

$$P = \text{Cos}\ \text{Ø}.\ I.\ V \text{ .... } (3.5)$$

Where: Cos Ø Power factor (being equal to 0.85);and

V= Voltage (220 volt).

3- Net consumptive power:

Net Power requirement was calculated by the following formula:

Net power = Electric power (load) - Electric power (no load)... (3.6)

Net consumptive energy was calculated by the following formula:

$$E = P / Fr \text{ .... } (3.7)$$

Where: E = Net power consumptive,

W. h /kg; P = Net power, W; and

Fr = productivity, kg/h.

4- Prototype productivity

Productivity for the developed prototype was calculated by using the following formula:-

Prototype productivity, (kg/h) = Q / t .... (3.8)

Where: Q = total tomato fruits mass, kg and T = operational time, h

5-Sortingefficienc:

The total sorting efficiency of the prototype was estimated according to (Klenin et al., 1985) and (Ismail, 1995 in Arabic reference) and using the following formula:

?G = (m1+m2+ m3+) x100 / m % ....(3.9)

Where: ?G = total prototype sorting efficiency(%),

m = total mass of fruit, kg and

m1, m2, and m3= weight of fruit in different collected sorting fruit from collected box A, B, and C, (kg).

RESULTS AND DISSCUSIONS

The results of this work are discussed under five factors:-

1. Physical and mechanical characteristics of tomato fruits.
2. Factors affecting on tomato sorting.
3. Power required and energy consumption.
4. Operational cost.

1- Physical characteristic of tomato fruit under study

A- Physical characteristics of tomato (Bito 86) can be summarized as follows:

Length ranged from 46.72 to 83.80 mm, width ranged from 40.15 to 80.62 mm, thickness ranged from 31.64 to 75.11 mm, geometric mean diameter (GM) ranged from 39.01to 79.76 mm, mass ranged from 80.14 and 180.12 g, aspect Ratio (AR) ranged from 85.94 to 96.62%, and surface area ranged from 47.78 to 199.76 cm2. The tilt angle for tomato fruits (Bito 86) was 14.0 'and 26.0 on rubber and galvanized iron respectively as shown in table (1).

B- Physical characteristics of tomato (zaina Rs692) can be summarized as follows:

Length ranged from 40. 76 to 62.74 mm, width ranged from 37.29 to 51.58 mm, thickness ranged from 31.78 to 50.64 mm, geometric mean diameter (GM) ranged from 36.42 to 54.72 mm, mass ranged from 71.18 and 165.73 g, aspect Ratio (AR) ranged from 82.21 to 85.80%, and surface area ranged from 41.65 to 94.20 cm2. The tilt angle was 16.0 and 29.0 for tomato fruits (zaina Rs692) on rubber and galvanized iron respectively as shown in table (2).

Table (1): Several physical properties of tomato (Bito 86)

Items	No	Mean	Range, max-Min	S.D.	C.V.%
Length : mm	100	64.6	83.80 – 46.72	±7.18	0.17
Width, mm	100	60.9	80.62 – 40.15	±6.81	0.12
Thickness ,mm	100	51.37	75.11 – 31.64	±7.28	0.16
Geometric diameter, mm	100	58.59	79.76 – 39.01	±6.97	0.11
Mass, g	100	124.70	180.12 - 80.14	±18.14	0.29
Aspect ratio, %	100	94.27	96.62 - 85.94	± 2.11	0.27
Surface area, cm	100	107.79	199.76- 47.78	±16.92	0.19

Table (2): Several physical properties of tomato (zaina RS692)

Items	No	Mean	Range, max-Min	S.D.	C.V.%
Length , mm	100	53.81	62.74 –40.76	± 4.21	1.12
Width, mm	100	45.18	51.58 – 37.29	± 2.18	0.78
Thickness, mm	100	38.11	50.64 – 31.78	± 3.54	2.01
Geometric diameter	100	45.25	54.72 -36.42	± 4.62	0.18
Mass, g	100	114.86	165.73 – 71.18	± 2.78	4.08
Aspect ratio, %	100	83.96	82.21 - 85.80	± 4.6	0.39
Surface area ,cm	100	62.24	94.2– 41.65	± 3.98	1.56

Factors affecting on tomato sorting:-

Sorting productivity:-

A - Tomato (Bito 86): -

Sorting capacity increased from 58.6-88.70,67.20-109.20,80.70-132.40 and 74.70-121.70kg/h at increasing feeding speed from 0.10,to 0.25 m/s and sensor height of 25 ,30 ,35 and 40 mm respectively. Also it was noticed that ,the maximum value of sorting capacity of (132.40kg/h) with feeding speed of(0.25 m/s) and 35mm for sensor height. Also the lower value of sorting capacity of (58.60 kg/h) was noticed with feeding speed of (0.10 m/s) at sensor height of (25 mm).

B - Tomato (zaina Rs692)

From the obtained data show that increasing feeding speed from 0.10 to 0.25 m/s , increased sorting productivity from 47.80 – 77.80 , 57.90 – 94.30 , 53.40 – 86.40, and 44.20 – 68.50kg/h under sensor height of 25 , 30 , 35 and 40 mm respectively. It was noticed that ,the maximum value of sorting capacity of (94.30kg/h) with feeding speed of(0.25 m/s) and 30mm for sensor height. While the lower value of sorting capacity of (44.20 kg/h) was noticed with feeding speed of (0.10 m/s) at sensor height of (40 mm).

4.2.2. Sorting efficiency:

A -Tomato (Bito 86): - Sorting efficiency decreased from 95.07 to 92.36, 95.84 to 93.66, 97.28 to 94.64, and 96.18 to 93.42% with increasing feeding speed from 0.10 to 0.25 m/s under sensor height of 25, 35, 35, and 40 mm respectively. Also It was remarked that Sorting efficiency increased with any increase in sensor height until 35mm and decrease with sensor height more than 35 mm. The maximum value of sorting efficiency is (97.48 %) with feeding speed of (0.10 m/s) and 35mm for sensor height. Also the lower value of sorting efficiency of (92.36 %) was noticed with feeding speed of (0.25 m/s) at sensor height of (25 mm).

B -Tomato (zaina Rs 692) : Also by increasing feeding speed from 0.10 to 0.25 m/s prototype sorting efficiency decreased with different sensor height . Sorting efficiency decreased from 96.17 to 94.78, 96.74 to 95.68, 96.07 to 94.69, and 95.46 to 93.55 % with increasing feeding speed from

0.10 to 0.25 m/s under sensor height of 25, 35, 35, and 40 mm respectively. Also It was remarked that Sorting efficiency increased with any increase in sensor height until 30mm and decrease with sensor height more than 30 mm. the maximum value of sorting efficiency of (96.74 %) with feeding speed of (0.10 m/s) and 30 mm for sensor height. Also the lower value of sorting efficiency of (93.55 %) was noticed with feeding speed of (0.25 m/s) at sensor height of (40 mm).

4.3. Power required and energy consumption.

Relating to the effect of feeding speed on energy requirement, the obtained data show that, by increasing feeding speed from 0.10 to 0.25 m/s, the energy requirement decreased from 3.83 to 2.97 and 5.35 to 4.25 kW.h/ton for two varieties of tomato crop, Bito 86 and Zaina Rs692 respectively.

4.4. Operational cost unit

The operation cost of sorting machine depended mainly on the sorting productivity, required power and workers. Referring to the effect of the previous factors operation cost equal 5.66 L.E / h.

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زكريا إبراهيم إسماعيل (١٩٩٥) محصول البطاطس – الزراعة – الحصاد –التداول- التخزين . منشاة المعارف بالإسكندرية.

الملخص العربي

فرز الطماطم طبقا للخواص الضوئية لمراحل نموها

محمد أحمد الشيخة، جمال السيد، هبه لطفى

قد لوحظ أن الفرز اليدوي له عيوب كثيرة أهمها التكلفة العالية للعمالة المدربة وعدم توافرها ، و انخفاض كفاءتها و معدل إنتاجها بالإضافة إلي تعرض المنتجات للتلوث و نظراً لعدم توفر ماكينات الفرز الصغيرة التي تناسب محطات الإعداد الصغيرة ، وعدم ملائمة ماكينات الفرز الكبيرة للارتفاع الهائل في أسعارها وكذلك عدم انتشار آلات الفرز الالكترونية المحلية الصنع, لذا أجريت هذه الدراسة التي تهدف إلي تقييم فرز ثمار الطماطم حسب اللون .

مكونات نموذج وحدة الفرز

١- الهيكل ٢- الحساسات الضوئية ٣ - دائرة التحكم الإلكترونية ٤- وحدة التغذية

عوامل الدراسة: وشملت عوامل الدراسة العوامل التالية

١-دراسة الخواص الطبيعية لنوعين من محصول الطماطم وهما (Bito86) و (zaina Rs692).

٢-أربع سرعات لسير التغذية (٠,١٠ ,٠,١٥ ,٠,٢٠، ٠,٢٥، م/ث).

٣- أربع ارتفاعات لوحدة الاضاءةوهى ٢٥و٣٠و٣٥و٤٠مم.

٤. عند سرعة ثابتة(١٠ م/ث) لتيار الهواء لدفع الثمار فى الأوعية المخصصة لها حسب لونها.

تقييم عملية الفرز: وقد تم تقييم الفرز لصنفين من الطماطم من خلال العوامل التالية

١- الإنتاجية (كجم/ساعة).

٢ - كفاءة الفرز (%).

٣- القدرة (ك وات) والطاقة اللازمة للفرز (ك وات ساعة / طن).

٤- التكاليف اللازمة لعملية الفرز (جنيه/ساعة).

وتوصلت الدراسة إلى النتائج الآتية:-

أولا: أهم الخصائص الطبيعية لأصناف الطماطم قيد الدراسة

١- الطماطم صنف (Bito 86) كان الأعلى فى نسبة انتظامية الشكل والمساحة الكلية للسطح والأقل فى زاوية الميل للثمار عن الصنف (zaina Rs692).

ثانيا: الانتاجية وكفاءة الفرز : لوحظ من النتائج أن الطماطم صنف Bito86 كان الأعلى فى الانتاجية وكفاءة الفرز عن الصنف (zaina Rs692).

ثالثا: الطاقة اللازمة لتشغيل النموذج

الطماطم صنف Zaina Rs 692كان الأكثر استهلاكا للطاقة عن الصنفBito 86.

رابعا : حساب تكاليف التصنيع والتشغيل

قد وجد أن التكاليف اللازمة لتشغيل الالة ٥,٦٦ جنيه/الساعة. وتتوقف تكاليف التشغيل حسب الانتاجية بالطن للالة الذى يتوقف على سرعة التغذية وارتفاع وحدة الاضاءة وصنف المحصول.

التوصيات

١- يجب أن تكون سرعة سير التغذية فى حدود من ٠,١٠-٠,١٥ م/ث حيث أنه عند هذه المعدلات نحصل على أفضل قيمة للكفاءة (٩٧,٤٨٪ -٩٦,١٨)للصنف Bito86 و(٩٦,٣٨-٩٦,٧٤ %) للصنف zaina Rs692

٢- هذا النموذج يمكن تنفيذه بحجم أكبر بخامات محليه منخفضة التكاليف و بكفاءة وانتاجية عاليه .

٣- امكانية استخدام هذا النموذج لفرز العديد من ثمار الخضر والفاكهة ويمكن ضبطة ليناسب فرز الثمار المختلفة .