# Investigation of classifying tomato seeds in drum screen

Wojciech KOPRAL, Wojciech POĆWIARDOWSKI, Marek DOMORADZKI, Joanna KANIEWSKA – Department of Technology and Apparatuses of Chemical and Food Industry, Faculty of Chemical Technology and Engineering, University of Technology and Life Sciences, Bydgoszcz

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**Nomenclature:**
A – constant
a – seed dimension, mm; m
g – acceleration of gravity, 9.81 m/s$^2$
h – height of a material's layer in a drum, m
n – rotary frequency, s$^{-1}$
P – through
R – drum diameter, m
S – feed of seeds
$x_p$ – feed fraction content
$x_s$ – through fraction content
$\alpha$ – raise seed angle in a drum, °
$\beta$ – angle of a drum inclination, °
$\eta_p$ – sieving efficiency
$p_u$- bulk density, kg/m$^3$
$\Theta$ – friction angle of seeds, °

## Introduction

Germination of seeds separated into fractions research proved that during laboratory tests as well as field tests seeds germination depends on a seed size [1, 2]. There is a perception that well-fully grown plant gives coarser seeds and crops with unripe (the smallest) and poorly germinating seeds have a worst quality. Seeds with similar dimensions when are sown give equalized in a term of a height crops [3]. The attention to a high quality crops caused a requirement on classified seeds. Most of seeds producing companies produce classified seeds packed in packages with 5 000, 10 000, 50 000, 100 000 or even 250 000 pieces.

To separate seeds into fractions, in a term of their size, devices called classifying (grading) screens are used [4÷7]. These are mostly sifters with screens of different construction:

- a frame screen
- a rotary screen
- a drum screen.

To classify (separate) vegetable seeds screens with round holes, set within following order, are used:

- small seeds holes diameter from 0.8 to 4.0 mm every 0.2 mm
- coarser seeds holes diameter from 2.0 to 5.0 mm every 0.5 mm
- beet seeds holes diameter from 2.0 to 5.0 mm every 0.25 mm.

A characteristic feature of the drum screen is slow tumbling motion of seeds related to the inner surface of the screen. A maximum rotary frequency of the drum should be less than a critical rotary frequency:

$$n \le \frac{1}{2 \cdot \pi}\sqrt{\frac{g \cdot \sin(\alpha - \Theta)}{R \cdot \sin\Theta}},\ s^{-1} \quad (1)$$

When a raise seed angle $\alpha$ in the drum amounts between 40 ° and 45° and an angle of friction of seeds by the screen $\Theta \approx 35°$ a simplified formula to calculate the critical rotary frequency can be taken up [8]:

$$n_{max} = \frac{0.13 \div 0.23}{\sqrt{R}},\ s^{-1} \quad (2)$$

A velocity of moving along the screen material depends on the rotary frequency of the drum, the angle of friction of material by screen surface, the angle of drum inclination and a rate of feeding. Hence a sieving efficiency can be determined like in the following formula [8]:

$$Q = A \cdot n \cdot tg \cdot (2 \cdot \beta) \cdot \rho_u \sqrt{R^3 \cdot h^3},\ kg \cdot h^{-1} \quad (3)$$

A quality of separating seeds into fractions – the sieving efficiency is defined as a ratio of a feed fraction content $x_p$ and through P product and through fraction content $x_s$ and seeds streams passed to the screen S product. The ratio is a measure of the drum screen running quality $\eta_p$

$$\eta_p = \frac{P \cdot x_p}{S \cdot x_s} \quad (4)$$

## Object of the study

The aim of this work was to determine drum screen running parameters which confirm high sieving efficiency, needed to separate tomato seeds, in a term of getting a similar size fraction.

## Materials and methods

Tomato seeds (*Lycopersicon esculentum*), variety named Paw, were studied material. A studied material sieve analysis was made by laboratory sieves. Furthermore the entire batch of seeds was separated into fractions in the drum screen by screens every 0.5 mm.

**Table 1**

**Sieve analysis of tomato seeds variety Paw**

| Screen hole diameter, a | Mass of fraction left on a screen | Vicarial diameter of fraction | Fraction part | Through (dumping), R |
|---|---|---|---|---|
| mm | g | mm | % | % |
| 4.5 | 0.0 | 4.74 | 0.00 | 0.00 |
| 4.0 | 0.1 | 4.24 | 0.08 | 0.08 |
| 3.5 | 1.3 | 3.74 | 1.07 | 1.15 |
| **3.0** | **15.3** | **3.24** | **12.57** | **13.72** |
| **2.5** | **92.3** | **2.74** | **75.84** | **89.56** |
| **2.0** | **12.1** | **2.24** | **9.94** | **99.51** |
| < 2.0 | 0.6 | 1.74 | 0.49 | 100.00 |
| total | 121.7 | total | 100.00 | |

From the batch of 6 fractions 3 fractions of diameters amounted 2.0-2.5, 2.5-3.0 and 3.0-3.5 mm were chosen for further research. Material for further studies was prepared from 1 kg of seeds of every chosen fraction. Then seeds were mixed together.

Screen drums with a diameter of 0.4 m with two screens long ca. 0.5 m showed in Figure 2 were made for tests. First screen needs to have holes with smaller diameter than a diameter of second screen holes.

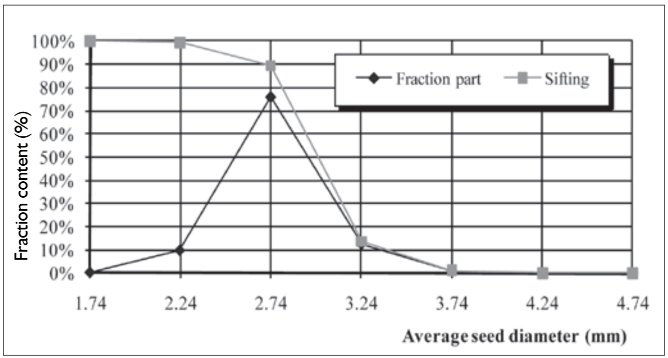


**Fig. 1. Results of tomato seeds variety Paw sieve analysis Drums**

## Screen drum construction

A cradle with a driver was mounted on a metal construction. Drums were fixed to the construction. Seeds were feed to the rotating drum by trough vibrating feeder. Material sifted through screen holes was poured to fraction receptacles. Coarse material was poured out of the drum to the receptacle.

The tested drum screen gives two fine fractions and a residue which is a mix of coarse fractions. Only one setting of the angle of the drum inclination amounted 8° was applied. The rotary frequency of the drum was changed by inverter which gave frequencies values of 0.22, 0.27, 0.33 and 0.38 $s^{-1}$.

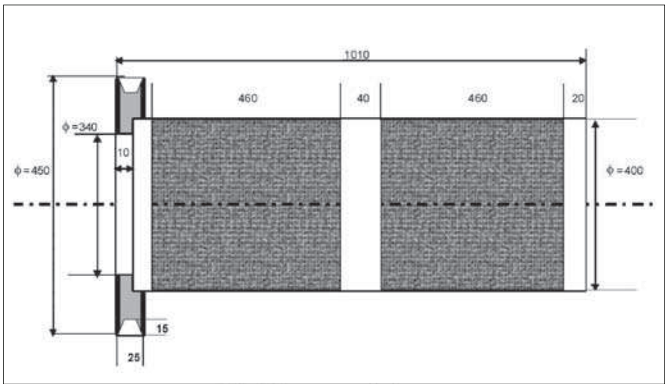


**Fig. 2. Drum screen's sieves**

A maximum value of the rotary frequency of the drum was determined according to the formula (2) and it amounted:

$n_{max}$ = 0.290÷0.737; $s^{-1}$.

The sieving efficiency was investigated by feeding tomato seeds with a different mass stream. Time of pouring ca. 3 kg seeds through the screen was measured. Results are presented in Figures 4÷6 and in Table 2.

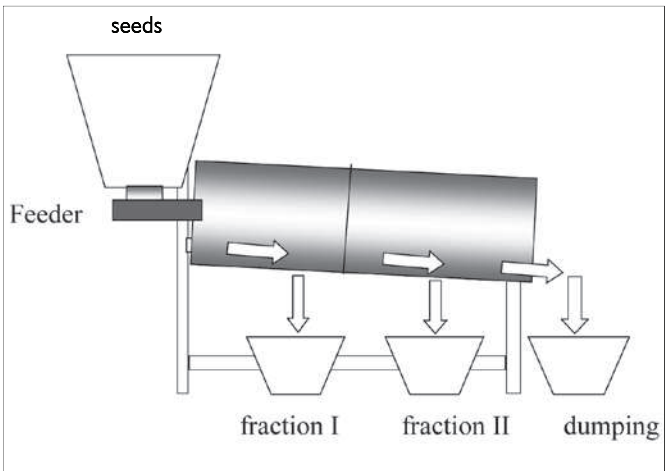


**Fig. 3.The scheme of seeds screen drum**

**Table 2**

**Sieving efficiency of tomato seeds by angle of inclination 8°**

| | Rotary frequency, n, $s^{-1}$ | Sieving efficiency, Q, $kg·s^{-1}$ | Sieving efficiency of 2.0-2.5 mm fraction, $n_{2.0-2.5}$ ,% | Sieving efficiency of 2.5-3.0 mm fraction, $n_{2.5-3.0}$ ,% | Sieving efficiency of 3.0-3.5 mm fraction, $n_{3.0-3.5}$ ,% |
|---|---|---|---|---|---|
| 1 | 0.22 | 0.00098 | 99.8 | 99.6 | 97.4 |
| 2 | 0.22 | 0.00122 | 99.6 | 99.3 | 96.3 |
| 3 | 0.22 | 0.00166 | 99.8 | 99.1 | 98.5 |
| 4 | 0.22 | 0.00206 | 99.8 | 99.3 | 96.9 |
| 5 | 0.27 | 0.00117 | 99.8 | 99.5 | 97.8 |
| 6 | 0.27 | 0.00156 | 99.5 | 99.2 | 97.3 |
| 7 | 0.27 | 0.00212 | 99.6 | 99.8 | 97.8 |
| 8 | 0.27 | 0.00241 | 99.2 | 96.9 | 93.4 |
| 9 | 0.33 | 0.00112 | 98.6 | 97.2 | 93.0 |
| 10 | 0.33 | 0.00148 | 94.9 | 90.2 | 98.3 |
| 11 | 0.33 | 0.00203 | 94.2 | 90,0 | 93.3 |
| 12 | 0.33 | 0.00251 | 94.2 | 80.9 | 92.9 |
| 13 | 0.38 | 0.00113 | 95.8 | 93.6 | 87.0 |
| 14 | 0.38 | 0.00157 | 94.2 | 92.3 | 90.2 |
| 15 | 0.38 | 0.00197 | 91.0 | 82.0 | 92.9 |
| 16 | 0.38 | 0.00231 | 98.1 | 91.6 | 97.9 |

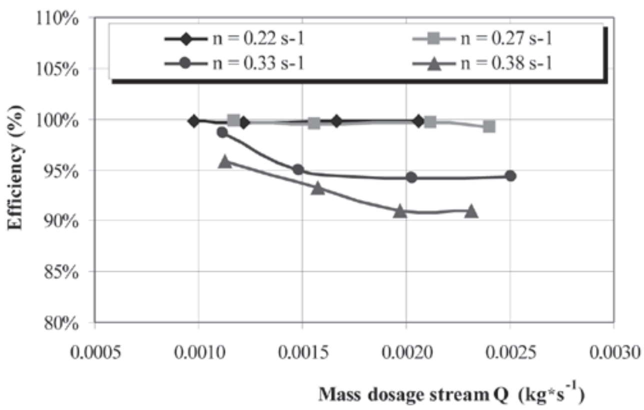


**Fig. 4. Sieving efficiency of 1st section with hole diameter 2.0 mm**

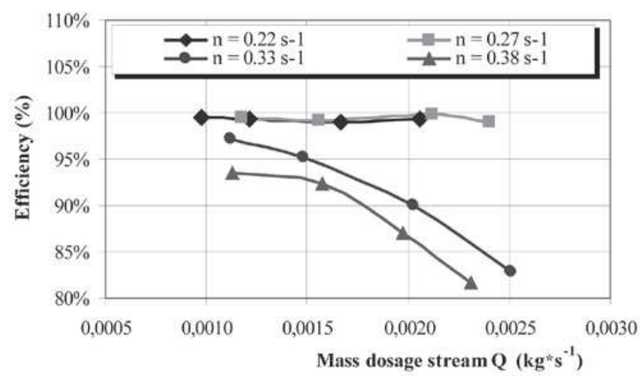


**Fig. 5. Sieving efficiency of 2nd section with hole diameter 2.5 mm**

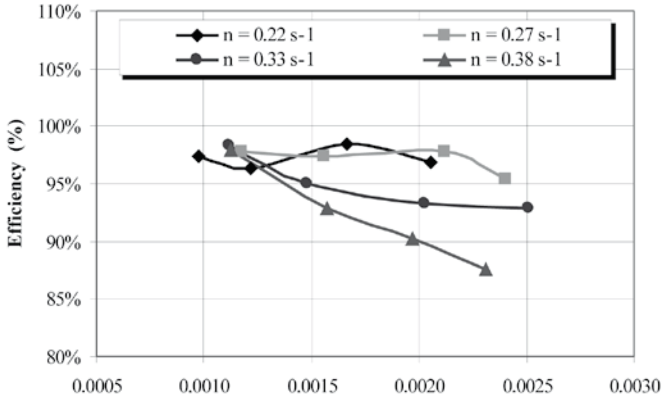


**Fig. 6. Sieving efficiency of seeds with diameter greater than 3.0 mm**

### Discussion of the results

When rotary frequencies are less than 0.27 $s^{-1}$ the sieving efficiency in high and in amounts not less than 97%. The efficiency does not depend on a mass seeds feeding stream when the stream is less than 0.0025 kg/s (ca. 9 kg/h). When the rotary frequency is greater than 0.27 $s^{-1}$ the sieving efficiency decreases and the decrease is greater when the mass stream of feeding. It may be noticed that threshold rotary frequency of 0.27 $s^{-1}$ well corresponds with the rotary frequency minimum value calculated by formula (1) given by Kagan (1974).

The sieving efficiency decrease is probably caused by the fact that the angle of raising seeds is bigger than the raise seed angle in the drum and instead of sliding down the drum surface seeds jump. This effect caused a drum active surface decrease.

### Conclusions

Studies allow to select the drum rotary frequency that provides high sieving efficiency to separate (classify) tomato seeds by the drum screen when the mass seeds' feeding stream is smaller than 9 $kg \cdot h^{-1}$.

The investigation shows that high efficiency of tomato seeds sieving is eligible the rotary frequency of the drum should amounts less than the maximum frequency described by the formula (2):

$$n_{max} = \frac{0.13}{\sqrt{R}}, \; s^{-1}$$

A precise separation of seeds in a term of their size requires high factors of the sieving efficiency.

### Literature


1. Pabis S., Pabis J.: *Technologia suszenia i czyszczenia nasion.* PWRiL Warszawa1984.
2. Woyke H., Sokołowska A., Szafirowska A.: Biul. Warzyw. XXXV Skierniewice 1990.
3. Woyke H., Sokołowska A.: Mat. Konf. ART Olsztyn1994., s. 245-250.
4. Grochowicz J. *Maszyny do czyszczenia i sortowania nasion.* W.A.R Lublin 1994.
5. Domoradzki M., Korpal W., Weiner W.: *Ciągły przesiewacz wibracyjny.* Konf. NT 2001. *Maszyny dla przetwórstwa płodów rolnych Pleszew.* Biuletyn Nr 2 (15) s. 43-48.
6. Domoradzki M., Korpal W., Weiner W.: *Badania kalibracji nasion warzyw. Materiały X Konferencji BEMS*. Lublin 2002. s. 45.
7. Domoradzki M., Korpal W., Weiner W.: *Badania kalibracji nasion warzyw.* Inżynieria Rolnicza 9, **42,** 75-82.
8. Kagan S.Z., Płanowski A.N., Ramm W.M. *Procesy i aparaty w technologii chemicznej.* WNT Warszawa1974.


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Wojciech KORPAL Sc.D. (Eng), graduated from the Faculty of Food Chemistry University of Łódź (1970). He earned his Ph.D. degree at the Department of Chemical Engineering, University of Łódź (1980). After several years working as a technician in the Chemical Plant „Zachm", then started work at the Faculty of Chemical Technology and Engineering at the College of Engineering-present University of Technology and Life Sciences in Bydgoszcz. His research interests focus on operations involving solids, sifting, agglomeration, and granular fertilizer technologies for controlled solubility.

Marek DOMORADZKI Ph.D.(Eng), is a graduate of Chemistry, Technical University of Łódź (1968). He earned his Ph.D. at the Department of Chemical Engineering, University of Łódź (1978). He currently works at the Faculty of Chemical Technology and Engineering University of Technology and Life Sciences in Bydgoszcz. Research interests - food industry equipment.

Wojciech POĆWIARDOWSKI M.Sc., is a graduate of Chemical Technology and Engineering UTP in Bydgoszcz and the Faculty of Health Sciences Collegium Medicum Nicolaus Copernicus University in Bydgoszcz. Currently, he is a Ph.D. student at the Faculty of Mechanical Engineering UTP in Bydgoszcz. Research interests - an analyst and biotechnology.


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