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Symbol		Unit
ρ_b	Bulk density of melon seeds	g/cm^3
ρ_r	Real density of melon seeds	g/cm^3
ε	The porosity of melon seeds	%
SFC	Static friction coefficient	--------
P	Machine productivity of seeds for melon seeds	kg/h
S_l	Seed losses	%
s_d	Seed damage	%
η_e	Extraction efficiency	%
E_{md}	Material discharge efficiency	%
E_o	Overall efficiency	%
η_{cl}	Cleaning efficiency	%
P_c	Power consumption	kW
SER	Specific energy require	kW.h/ton

5. SUMMARY AND CONCLUSION

This study was carried out during season 2013/2014, which includes two parts. Physical and mechanical properties are determined for melon seeds, melon seeds fruit and extraction processes. Determined physical and mechanical properties for melon seeds were carried out at Rice Mechanization Center, Meet El-Deeba, Kafrelsheikh Province. While, extraction process was carried out during season 2014/2015 at El-etehad village, Kafrelsheikh governorate. The manufactured prototype consists of frame, feeding hopper, crushing and extracting unit, peels outlet, conveying auger of seeds, cleaning brushes and seeds outlet. The prototype evaluation done based on machine productivity, extraction efficiency, cleaning efficiency, seed damaged, power consumed, and operational cost. This study has included the following specific objectives:

1. To develop a mechanical melon seeds extractor, which will improve the quality and quantity of extracted melon seeds and reduce drudgery.
2. To evaluate the extraction prototype based on cleaning efficiency, extraction efficiency, machine productivity, power consumed and seed damaged.
3. To calculate cost effectiveness and estimate of economic impact of manufactured prototype.

Performance of the extraction machine was evaluated under the following parameter:

a. Five drum speeds (3.25, 5.47, 6.98, 8.52, 10.64 m/s,) (345, 580, 740, 903 and 1130 rpm, respectively).

b. Four feeding rates (20, 30, 40, 50 kg/min) and

c. Four Time-spans of extracting after harvesting (0, 3, 6, 9 days).

The experiments were carried out with three replicates to evaluate the extraction performance in the following terms: cleaning efficiency, extraction efficiency, machine productivity, material discharge efficiency, overall efficiency, power requirements, seed damage percentage, seed losses percentage and cost estimation.

The following conclusions are drawn from the study:

1. The machine productivity, kg/h, decreased by increasing crushing drum speed, it had directly proportional to feed rate and melon seeds time span. The highest value of machine productivity of seed was 152.14 kg/h at crushing drum speed of 3.25 m/s; feed rate of 50 kg/min and melon seeds time span 9 days. However, the lowest value of machine productivity was 49.36 kg/h at crushing drum speed of 10.64 m/s; feed rate of 20 kg/min and melon seeds time span 0 day.
2. The seed losses. %, increased by increasing crushing drum speed and melon seeds feed rate. Whereas it had inversely proportional of melon seeds time span. The highest value of seed losses were 7.82 % at crushing drum speed of 10.64 m/s; feed rate of 50 kg/min and melon seeds time span 0 day. Where the lowest value was 1.15 % at crushing drum speed of 3.25 m/s; feed rate of 20 kg/min and melon seeds time span 9 days.
3. The seed damage. %, increased by increasing crushing drum speed whereas, it had inversely proportional to crop feed rate and melon seeds time span. The highest value of seed damage was 5.22 % at crushing drum speed of 10.64 m/s; feed rate of 20 kg/min and melon seeds time span 0 day. Where, the lowest value was 1.53 % at

crushing drum speed of 3.25 m/s; feed rate of 20 kg/min and melon seeds time span 9 days.

4. The extraction efficiency, %, decreased by increasing crushing drum speed while, it had inversely proportional to crop feed rate and melon seeds time span. The highest value of extraction efficiency was 98.85 % at crushing drum speed of 3.25 m/s; feed rate of 20 kg/min and melon seeds time span 9 day
5. The material discharge efficiency, %, decreased by increasing crushing drum speed while, it had inversely proportional to crop feed rate and melon seeds time span. The highest value of material discharge efficiency was 52.44 % at crushing drum speed of 3.25 m/s; feed rate of 20 kg/min and melon seeds time span 0 day. Meanwhile, the lowest value of material discharge efficiency was 16.07 % at crushing drum speed of 10.64 m/s; feed rate of 50kg/min and melon seeds time span 9 day
6. The overall efficiency. %, decreased by increasing crushing drum speed, also it had inversely proportional to crop feed rate and melon seeds time span. The highest value of overall efficiency was 50.48 % at crushing drum speed of 3.25 m/s; feed rate of 20 kg/min and melon seeds time span 0 day. Meanwhile, the lowest value of material discharge efficiency was 15.21 % at crushing drum speed of 10.6 m/s; feed rate of 50 kg/min and melon seeds time span 9 day
7. The cleaning efficiency, %, increased by increasing crushing drum speed while, it had inversely proportional to crop feed rate and directly proportional to melon seeds time span. The highest value of cleaning efficiency was 88.83 % at crushing drum speed of 10.64 m/s; feed rate of 20 kg/min kg/h and melon seeds time span 9 days. Meanwhile, the lowest value of cleaning efficiency was 74 % at

crushing drum speed of 3.25 m/s; feed rate of 50 kg/min and melon seeds time span 0 day

8. The power consumption, kW, increased by crushing drum speed and melon seeds feed rate, whereas, it had inversely proportional to melon seeds time span. The highest value of power consumption was 5.98 kW at crushing drum speed of 10.64 m/s; feed rate of 20 kg/min and melon seeds time span 0 day. While, the lowest value was 2.61 at crushing drum speed of 3.25 m/s; feed rate of 50 kg/min and melon seeds time span 9 days.

9. The specific energy, kW.h/Mg, increased by crushing drum speed and melon seeds feed rate whereas, it had inversely proportional to melon seeds time span. The highest value of specific energy was 92.99 kW.h/Mg at crushing drum speed of 10.64 m/s; feed rate of 20 kg/min and melon seeds time span 0 day. While, the lowest value was 21.05 kW.h/Mg at crushing drum speed of 3.25 m/s; feed rate of 50 kg/min and melon seeds time span 9 days.

10. The total cost, LE/kg, increased by melon seeds time span whereas, it had inversely proportional to crushing drum speed and melon seeds feed rate. The highest value total cost was 0.68 LE/kg at crushing drum speed of 10.64 m/s; feed rate of 20 kg/min and melon seeds time span 0 day. Meanwhile, the lowest value was 0.21 LE/kg at crushing drum speed of 3.25 m/s; feed rate of 50 kg/min and melon seeds time span 9 days.

11. A multiple regression analysis was made taking cleaning efficiency (η_c), extraction efficiency (η_e), machine productivity (M_p), seed damage (S_d), and power consumption (P_c), as dependent variables and time span of melon seed, melon seeds feed rate and crushing

drum speed as independent variables. The regression equation was as follows:

$$Y= a_0 + b_1\ T.S + b_2\ F.R + b_3\ C.S \quad \ldots\ldots\ldots\ldots (5.1)$$

Where:

Y = dependent variable,

T.S = time span of melon seeds, day, $(0 \le TS \le 9)$,

F.R. = Melon seeds feed rate, kg/min, $(20 \le F.R \le 50)$

C.S = crushing drum speed, m/s, $(3.25 \le S \le 10.64)$

a_0 = Constant and

a_1, b_2 and b_3 = regression coefficients.

Table 5: Multiple regression coefficients for the output parameters of the extraction machine during experiments.

Dependent variable (Y)	a_0*	Regression coefficients			R^2
		b_1	b_2	b_3	
Machine productivity	2.320	0.980	2.680	- 1.150	0.993
Seed losses	2.220	-0.380	0.085	0.110	0.970
Seed damage	5.640	-0.950	-0.056	-0.520	0.820
Machine discharge	68.820	-1.016	-0.034	2.450	0.880
Overall efficiency	66.480	-0.856	-0.360	2.330	0.880
Extraction efficiency,	97.660	0.330	-0.087	- 0.075	0.972
Cleaning efficiency	80.180	1.08	-0.112	- 0.085	0.697
Power consumption	0.635	-0.970	0.044	0.029	0.960

* a_0 = constant a_1, b_2 and b_3 = regression coefficients

Applied recommendations:

1. The best performance for the extraction machine were obtained at crushing drum speed of 3.25 m/s feed rate of 20 kg/min and melon seeds time span of 9 days, where it gave the following results:
    a. Machine productivity of 152.14 kg/h.
    b. Seed losses of 1.15%.
    c. Seed damage of 1.53 %.
    d. Extraction efficiency of 98.85 %,
    e. Material discharge efficiency of 52.44 %.
    f. Overall efficiency of 50.48 %.
    g. Cleaning efficiency of 88.83 %.
    h. Specific energy of 21.06 kW.h/Mg.
    i. Total cost of 0.21 LE/kg.

The study strongly recommended to use mechanical extraction using the prototype for melon seeds due to the labor shortage during the harvesting time. .