DEVELOPMENT OF GRINDING MACHINE SUTABLE FOR MANGO KERNEL

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ABSTRACT

The grinding process of agricultural wastes is important process to produce pre-materials for many uses. The aim of this study was develop and evaluate the grinding machine performance suitable for mango kernels as hard wastes. The average of mango kernel per pulp ratio was about 74.5%. The main dimensions were 53.88±7.43, 20.42±3.21 and 10.98±1.89 mm at length, width and thickness, respectively, The spherisity was (75.5±20.39 %), geometric (4.1±1.25mm) and arithmetic (28.43±3.01mm) diameters, surface area (56.9±34.3mm^2), coefficient of frictions on galvanized, iron black painted and iron sheet were about 0.649, 0.577 and 0.675 respectively, hardness (444.64±118.24N) and shear strength (224.62±98.65N). The studied factories include feeding quantity "F" of 10, 15 and 20kg, drum speeds "S" at 1500, 2000, 2500 and 3000 rpm (28.26, 37.68, 47.10 and 56.52 m/s) and knives number "N" of 24, 36 and 48 knives. The grinding machine performance was estimated by determine the product quality (grinding residual distribution and mean weight diameters "MWD") and the machine performance (machine productivity, power consumed and energy requirement). From the obtained results it can be concluded that the grinding machine can be manufactured and used to grinding the local mango kernel at the feeding quantity of 20 kg, drum speed of 2000 rpm and knives number of 36 to obtain the homogeneous size distribution with less "CV" of 4.3, 11.22 and 12.26% respectively and at these studied parameters the MWD machine productivity, power consumed and specific energy requirement are 1.309mm, 2.94Mg/h, 3.60kW and 1.22kW.h/Mg respectively. The developed grinding machine which manufacture from a locally materials can be tested to grind many solid wastes to increase the developed grinding machine reliability.

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INTRODUCTION

Grinding process is one of the basic operations dealing with agricultural wastes to reduce the volume of waste in order to facilitate trading, transportation and manufacturing process for processes for preparation of the product. **El-Dorghamy (2010)** estimated that the amount of agricultural waste in Egypt ranges from 30 to 35 million tons. Some of the agricultural waste is used as animal fodder, wood manufactured and biogas production. **Campbell (2007)** said that the quantity of crop residues in Egypt was 40 million ton/year, beside 8 million ton/year of horticultural according to the statistical survey of the Egyptian Ministry of Agriculture (2012). Egypt produces about 534.434 tons of mangoes annually (Central Administration for orchards and crops 2010).which yield about 240 thousand tons of seeds. **Soong and Barlw (2006), Maisuthisakul and Gordon (2009) and Kim et al. (2010)** reported that the mango seed represents from 20% to 60% of the whole fruit weight, depending on the mango variety and the kernel inside the seed which represents from 45% to 75% of the whole seed. In the food processing industry, considerable quantity of seed is discarded as waste, after the extraction of mango pulp. Mango seed kernel is a good source of phenolic antioxidants, metal chelators and tyrosinase inhibitors. **Mahmoued (2005)** analyzed the seed kernels of mango (*Mangifera indica* local variety) and reported that the seed kernels contained 12% moisture, 4.1% protein, 7.6% lipid, 75.5% carbohydrate, 10.3% crude fiber, 2.5% ash , 0.3% tannins. of K (16.8), Na (7.6), Ca (3.5), P (0.30) mg/100g.The advantage of mango kernels can be used as sweets flavor (**Ashoush and Gad-Alla, 2011**), poultry feed (**Diarra, et al., 2011**), and ruminants feed (**Aregheor, 1998**) and silage (**Naveen, et al., 2006**). The all uses of mango kernels should change it to particles by grinding or crushing machine. **Hall and Davis (1979)** classified mill equipments which for mango kernel size reduction into four types: Hammer mill, burr mill, combination mill and roller mill .Hammer mill consists of fixed or swinging hammers mounted on rotating shaft, screen and fan. These hammers are 2.5 to 7.5 cm (1 to 3 in) apart and rotate at 2500 to 4000 rpm depending on the diameter of hammers. **Aly and Dimian (1988) and El-Hadidi *et al*. (1997)** reported that power requirement and milling capacity are affected by material, moisture content, fineness of grinding, rate of feed and type mill. They added that hammer mill reduces the size by impact, while burr (plate) mill reduces the size by crushing and shear forces. They concluded that no significant differences were found between mills with respect to fineness degree while Medium fineness degree of (3.0 – 4.2 mm) was increased using burr mill and hammer mill compared with other types of mills. **Deaton *et al.* (1989)** used hammer mill with a full- circle screen with 4.8 mm round hole. It was operated by a 14.9 kW. motor rotated at approximately 3450 rpm. The particle size for corn processing with the hammer mill ranged from 0.81 to 0.87 mm. **El-Ashhab *et al.* (2003)** used a swinging hammer mill for grinding corn, horse bean and date stones for feed ration.They found that energy required to grind one ton corn grains at 4000 rpm was duplicated when replacing the screen hole diameter 7.5 mm with another one 3.6 mm .**Sci-Tech Dictionary (2003)** mentioned that conventional hammer mill is a device consisting of a rotating head with free-swinging hammers, which reduce rock, grains or similarly hard objects to a predetermined size through a perforated screen. Hammer mills are widely utilized in the agricultural, wood, mining and chemical industries**. FAO (2006)** reported that the Hammer mills are very common throughout Africa. As the name implies, hammers in the mill grind grains through impact. A hammer mill consists of a large cylinder with a horizontal shaft that drives a rotor with several rows of free-swinging hammers. The hammers rotate inside a perforated metal screen through which the flour is drawn. **McCabe et al. (1993)** reported that size reduction equipment was divided into crusher, grinders, ultra-fine grinders and cutting machines. On the other hand **Sun (2002)** said that the size of waste-materials is usually 10 to 30 mm after chipping and 0.2 to 2.0 mm after milling or grinding. **Fife *et al.* (2010)** found that the grinding this is processing by which material is reduced in particle size by impact, shearing or attrition. Grinding is normally accomplished using a hammer mill, with particle size controlled by screen size, hammer mill size and moisture content of the grain. Grinding the most common, cheapest, and simplest method of grain processing.

The aim of the present study is to develop and evaluate the grinding machine performance suitable for mango kernels as hard wastes.

MATERIALS AND METHODS

To achieve the goal of this study a grinding machine consists of feeding unit, suitable frame and power source was construction in Agricultural Engineering Research Institute (AEnRI) workshop (Fig1 and 2) for grinding mango kernel (*Mangifera indica* local variety) obtained from Farag Allah company through 2009-2010.

(1) Frame was fabricated from 50 × 50 ×5 L mm steel 37C.The frame dimensions are 680 × 1150 × 1000mm length, width and height, respectively.

(2) Feeding unit was fabricated from steel sheets 2mm thickness as trapezoid shaped. The feeding unit was supported from the down end with the frame inlet at 60 degree inclination angle by knuckle. The feeding unit dimensions are 745 × 400 × 265 mm, length, width and height, respectively.

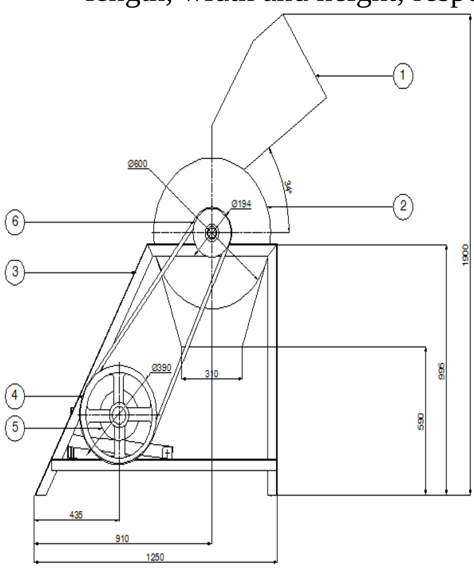

Fig.1: elevation view of the grinding machine.

1- Feed hopper 2- housing 3- frame
4 -Motor pulley 5- Motor 6- Driving pulley

Fig.2: The grinding machine photographed.

(3) Grinding unit consists of:

- Case: It cylindrical shape with two opens; the inlet has dimensions of 300 × 200 mm and the outlet open has dimensions of 310× 200 mm length and width, respectively.
- Drum consists of main shaft, four flanges and bins.

- Knife made from spring steel with 100mm length, 45mm width and 8mm thickness. The knives are mounting as a groups between the flanged each group include two knives.
- Screen holes is 6mm and number of holes per square inch is 9 holes. The clearance between the knives and the screen is 10mm.

(4) Electrical motor of 3.677 kW (5 hp) was used to the grinding machine. The power was transmitted by pulley and belt.

The experiments were done in randomized complete block design at three replicates to determine the grinding machine performance under the studied factories. The following factories include:

1- Feeding quantity "F" (10, 15 and 20kg).
2- Drum speeds "S"(1500, 2000, 2500 and 3000 rpm).
3- Knives number "N" (24, 36 and 48 knives).

Experiments were done to show the effect of drum speeds "S", knives number "N" and feeding quantity "F" on the grinding machine performance. The grinding machine performance was estimated by determining the product quality (grinding residual distribution and mean weight diameters "MWD") and the machine performance (machine productivity, power consumed and energy requirement).

Measurements

a. Mango kernels properties

The length, width and thickness of 100 mango kernels measured by digital venire caliber with an accuracy of 0.05mm. Then the mango kernel properties are determined using the following equations (Mohsenin, 1998):

- Sphericity:

$$\phi = \frac{Dg}{L} = \frac{(L.W.T)^{1/3}}{L} \quad (\%) \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where: Dg = Geometric mean diameter, mm

L = Mango kernel length, mm

W = Mango kernel Width, mm

T = Mango kernel thickness, mm

- Geometric mean diameter (Dg) and the arithmetic mean diameter (Da) (c.t. Seyed and Elnaz, 2006):

$$Dg = (L.W.T)^{1/3} \ldots\ldots\ldots\ldots (mm) \ldots\ldots 2$$

$$Da = \frac{L + W + T}{3} \ldots\ldots\ldots\ldots (mm) \ldots\ldots 3$$

- ***Surface area (As):***

$$A_s = 2\pi(L.W) \ldots\ldots\ldots\ldots mm^2 \ldots\ldots 4$$

- ***Moisture content*** was determined by drying at 70° **(AOAC, 2000)**

$$M_c = \frac{M_w - M_d}{M_d} \times 100 \ldots\ldots\ldots\ldots 5$$

Where:

M_c = Mango kernel moisture content, %

M_w = Sample mass before drying (g)

M_d = Mass after drying sample (g)

- ***Percentage of kernels*** per pulp using 100 mango fruits. Was determined e following equation.

$$Mango\ kernel\% = \frac{Mango\ kernel\ weight}{Mango\ fruit\ weight} \times 100 \ldots\ldots\ldots 6$$

- ***Kernel coefficient of friction*** was measured using measuring device on three surface iron black painted, iron and galvanized iron sheets. The angle of friction was measured and the coefficient of friction was calculated from the flowing equation. (Mohsenin , 1998)

$$\mu = \tan\theta \ldots\ldots\ldots\ldots 7$$

Where: μ = coefficient of friction.

θ = the friction angle.

- ***Hardness and shear strength*** was measured by the digital force gauge for ten kernels.

b. Grinding machine performance

Product quality

- ***Mean weight of diameters (MWD)*** were estimated by using the sieve apparatus. After sieving all the individual particles are weighed and all the portions are calculated according to RNAM (1983) to determine MWD:

$$MWD = \frac{1}{W}(3.35A + 1.4B + 1.5C + 0.68D + NF) \ldots\ldots\ldots\ldots 8$$

Where: MWD = Mean grinding mango kernel diameter, mm
W = Weight of grinding crops residue (A + B + C + D + F), kg
N = Mean of measured diameters of grinding crops residue retained on the largest aperture sieve, mm

- ***Grinding residual distribution*** of the output product was determined using three standard sieves (3.35, 1.40, 0.68 and <0.68) (ASAE, 2001). The total weight of samples and the mass of each product categories were weighed using a digital scale balance with an accuracy of 0.01g.

Machine performance

- ***Grinding machine productivity*** **"Pr"** was calculated using the following formula:

$$P_r = \frac{W \times 3600}{t}, \text{Mgh}^{-1} \quad \text{...9}$$

Where: Pr = Productivity, Mgh^{-1}.
W= Mass of the sample, Mg.
t = Consumed time, h

- ***consumed Power (kW)*** was calculated using the following formula of: (Ibrahim, 1982)

$$\text{P} = \frac{1.73 \;\; I.V.\eta.Cos\theta}{1000} \quad \text{..10}$$

Where: I = Line current strength in amperes.
V = Potential difference (Voltage) being equal to 380 V.
$Cos\ \theta$ = Power factor (being equal to 0.84).
$\sqrt{3}$ = Coefficient current three phase (being equal 1.73).
η = Mechanical efficiency assumed (95 %).

- ***Specific energy requirment*** **(E)** calculated using the ollowing equaion:

$$\text{The specific energy requirement} = \frac{\text{The consumed power (kW)}}{\text{Actual capacity (Mg/h)}} \quad \text{...............11}$$

c- Statistical analysis

Microsoft Excel 2010 computer program was use to carry out the multiple regression analysis to represent the relation between each of MWD, machine productivity , consumed energy, power requirement and all of feeding quantity, drum speed and knives number.

RESULTS AND DISCUSSION

a- Mango kernels properties

The average of mango kernel ratio was 74.5% from the mango seeds, while the seed casing is was 25.5%. the mango kernel moisture content was 12.0%. Figs (3and5) illustrate the frequency of the main dimensions of mango kernel are 53.88±7.43, 20.42±3.21 and 10.98±1.89 mm at length, width and thickness, respectively. Some properties of mango kernels were measured and its results are tabulated in Table (1)

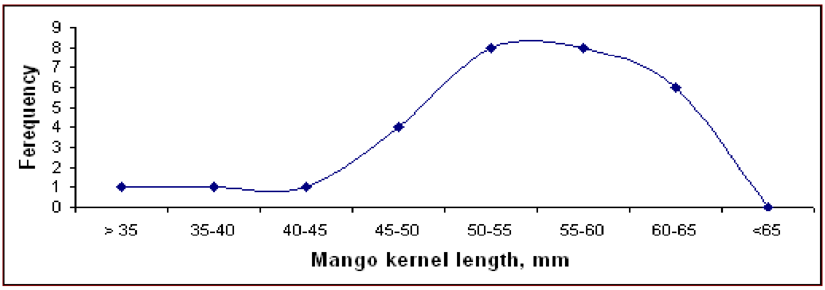

Fig. 3: The Mango kernel length frequency.

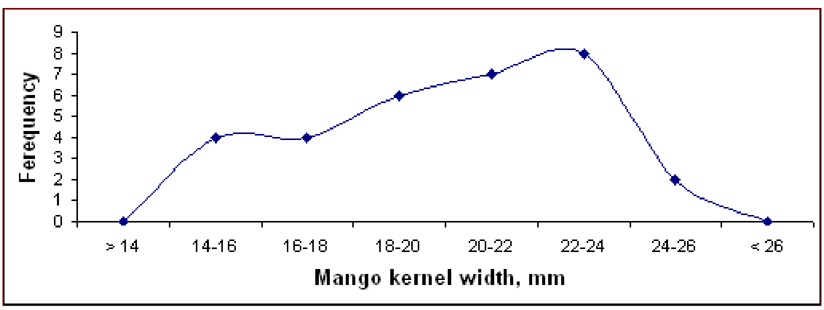

Fig. 4: The Mango kernel width frequency.

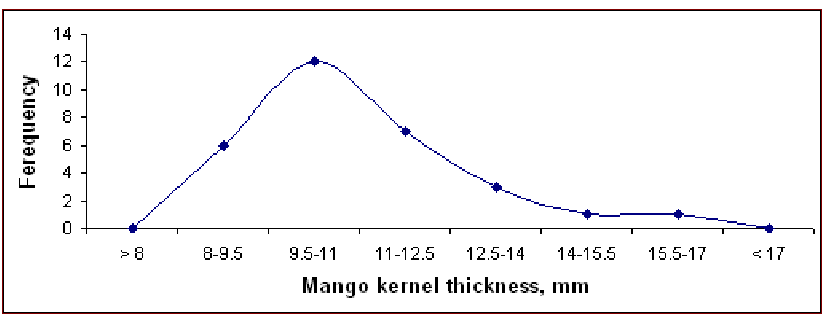

Fig. 5: The Mango kernel thickness frequency.

Table 1: The mango kernel engineering properties

Engineering properties	Mean $^{\pm SD}$	Maximum	Minimum	CV, %
Spherisity, %	$75.50^{\pm 20.39}$	130.16	44.60	27.14
Geometric mean diameter, mm	$4.10^{\pm 1.25}$	7.01	2.12	26.50
Arithmetic mean diameter, mm	$28.43^{\pm 3.01}$	33.50	22.05	9.41
Surface area, mm^2	$56.93^{\pm 34.3}$	19.75	11.56	13.54
Coefficient of friction				
iron sheet galvanized	0.649			
iron black painted	0.577			
iron sheet	0.6745			
Hardness	$444.64^{\pm 118.24}$	594.00	243.10	31.46
Shear Strength	$224.62^{\pm 98.65}$	399.00	125.50	78.65

b. Grinding machine performance

1- Effect feeding quantity, drum speed and knives number on grinding residual distribution

Figs from (6) to (8) illustrate that the effect of studied variables on grinding residual distribution at different sieves hole diameters. From the figures it can be seen that by increase feeding quantity, drum speed and knives number the average of grinding residual decreased at sieves diameters of 3.35 and 1.4 mm, while the inverse trend obtained at sieves diameters of 0.68 and > 0.68 mm. Therefore, Fig. (6) shows that at feeding quantity of 10 kg the average of grinding residual distribution are 15.9, 29.28, 26.73 and 28.08% respectively at sieves diameters of 3.35, 1.40, 0.68 and > 0.68 mm. Then the corresponding results at 15 and 20 kg feeding quantity are 16.94, 24.91, 27.96 and 30.19 % and 13.55, 27.44, 29.85 and 29.16 %, respectively. On the other side, Fig.(7) cleared that the increase in drum speed from 1500 to 3000 rpm the average of grinding residual distribution decrease from 18.91 to 10.11 and from 34.93 to 18.52 %, respectively at sieves hole diameters of 3.35 and 1.40 mm. Contrary, the increase in drum speed from 1500 to 3000 rpm the average of grinding residual distribution increase from 24.16 to 28.83 and from 21.99 to 42.54 % respectively at sieves hole diameters of 0.68 and >0.68 mm. However, Fig.(8) shows that the increase in knives number from 24 to 48 the average of grinding residual distribution decrease from 20.69 to 11.46 and from 34.52 to 22.55 %, respectively at sieves hole diameters of 3.35 and 1.40 mm. On the opposite side, the increase in knives number from 24 to 48 the average of grinding residual distribution increase from 22.68 to 30.90 and from 22.11 to 35.08 %, respectively at sieves hole diameters of 0.68 and >0.68 mm. These results explain that the drum speed and the knives number are the effective variable on the grinding residual distribution while the feeding quantity is the less effect. The coefficient of variance for the grinding obtained from the sieves diameters ranging from 1.4 to > 0.68 mm; according to Sun (2002); conducted that the lowest "CV" were 4.30, 11.21 and 12.26 % obtained at feeding quantity of 20 kg, drum speed of 2000 rpm and knives number of 36 knife.

2- Effect of studied variables on mean weight diameter (MWD)

Fig. (9) cleared that the effect of drum speed on mean weight diameter at different knives number and feeding quantity. From the figure it can be seen that the grinding MWD has an inversally proportional to feeding quantity, drum speed and knives number. Meanwhile, the grinding MWD decreased from 1.49 to 1.12, 1.42 to 1.11 and 1.43 to 1.01 mm by increase the drum speed from 1500 to 3000 rpm respectively at 10, 15 and 20 kg feeding quantity. In the same trend the grinding MWD decreased from 1.50 to 1.19, 1.57 to 1.14 and 1.37 to 1.14 mm by increase the knives number from 24 to 48 respectively at 10, 15 and 20 kg feeding quantity. Therefore, at feeding quantity 10, 15 and 20 kg the grinding MWD were 1.31, 1.30 and 1.25mm respectively. These results trend is logically which clear the slightly effect of the decrese at the change of feeding quantity while the effect is incresed at changes the both of drum speed and knives number. Using the multiple regression analysis the relation between the all levels of feeding quantity "F", drum speed "S", knives number "N" and the grinding mean weight diameter (MWD) can be shown as the following linear regression equation:

$$MWD = 0.0431\ F + 0.0001\ S + 0.0073\ N \qquad (R^2 = 0.9180)$$

The analysis of variance for the data of MWD at different of feeding quantity, drum speed and knives number indicated a high significant between the treatments with (R^2 = 0.9180).

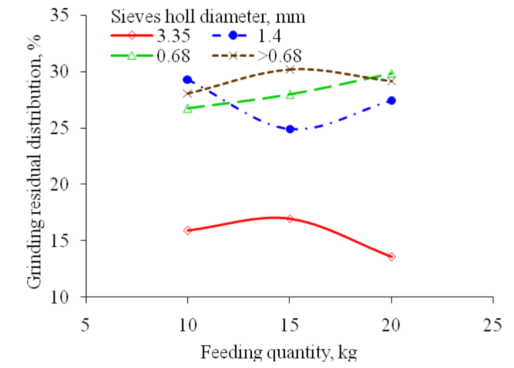

Fig. 6: Effect of feeding quantity on grinding residual distribution.

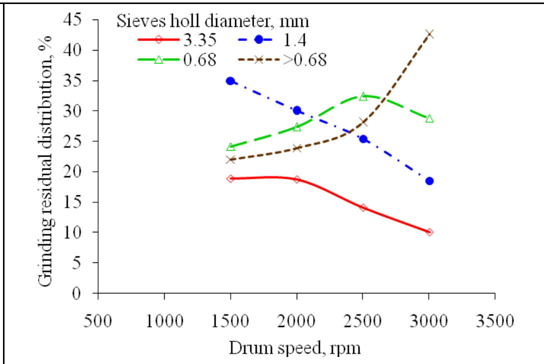

Fig. 7: Effect of drum speed on grinding residual distribution.

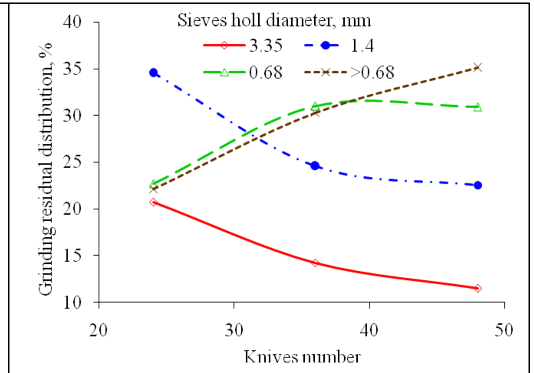

Fig. 8: Effect of knives number on grinding residual distribution.

Feeding quantity "kg"; 10 | 15 | 20

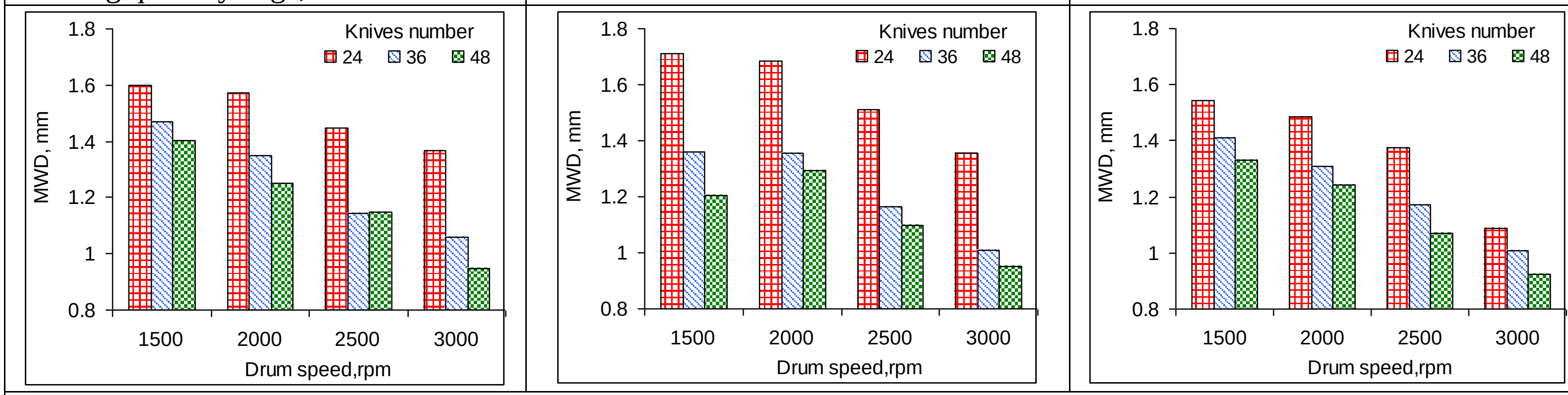

Fig. 9: Effect of drum speed on mean weight diameter at different knives number and feeding quantity.

3- Effect of studied variables on grinding machine productivity

Fig. (10) describe that the effect of drum speed on grinding machine productivity at different feeding quantity and knives number. The figure clear that the grinding mchine prouctivity has a directly proportional to all levels of feeding quantity, drum speed and knives number. Moreover, the average of grinding machine productivity increased from 1.85 to 3.19Mg/h by increasing the feeding quantity from 10 to 20 kg at neglected the both of drum speed and knives number. Hence the average of grinding machine productivity increased from , 2.40 to 2.64Mg/h by increasing the drum speed from 1500 to 3000 rpm at neglected both of the feeding quantity and knives number. Consequently, the average of grinding machine productivity increased from 2.10 to 3.01Mg/h by increasing the knives number from 10 to 20 kg at neglected the bothe of feeding quantity and drum speed.

Using the multiple regression analysis the relation between the all levels of feeding quantity "F", drum speed "S", knives number "N" and the grinding machine productivity (P) can be shown as the following linear regression equation:

$$P = 0.000003\ F + 0.02465\ S + 0.11115\ N \qquad (R^2 = 0.9832)$$

The analysis of variance for the data of grinding machine productivity at different of feeding quantity, drum speed and knives number indicated a high significant between the treatments with (R^2 = 0.9832).

4- Effect of studied variables on power consumed

Fig. (11) explain that the effect of drum speed on power consumed at different knives number and feeding quantity. From the figure it can be seen that the power consumed has a directly proportional to feeding quantity, drum speed and knives number. Moreover, the power consumed increased from 4.32 to 9.59, 4.66 to 9.77 and 4.76 to 10.67 kW by increase the drum speed from 1500 to 3000 rpm, respectively at 10, 15 and 20 kg feeding quantity. On the other hand, the power consumed increased from 2.575 to 11.135, 2.712 to 11.135 and 2.850 to 12.43 kW by increase the knives number from 24 to 48, respectively at 10, 15 and 20 kg feeding quantity. Then, at feeding quantity 10, 15 and 20 kg the power consumed were 6.38, 6.51 and 7.03 mm, respectively.

Knives number; 24 | 36 | 48

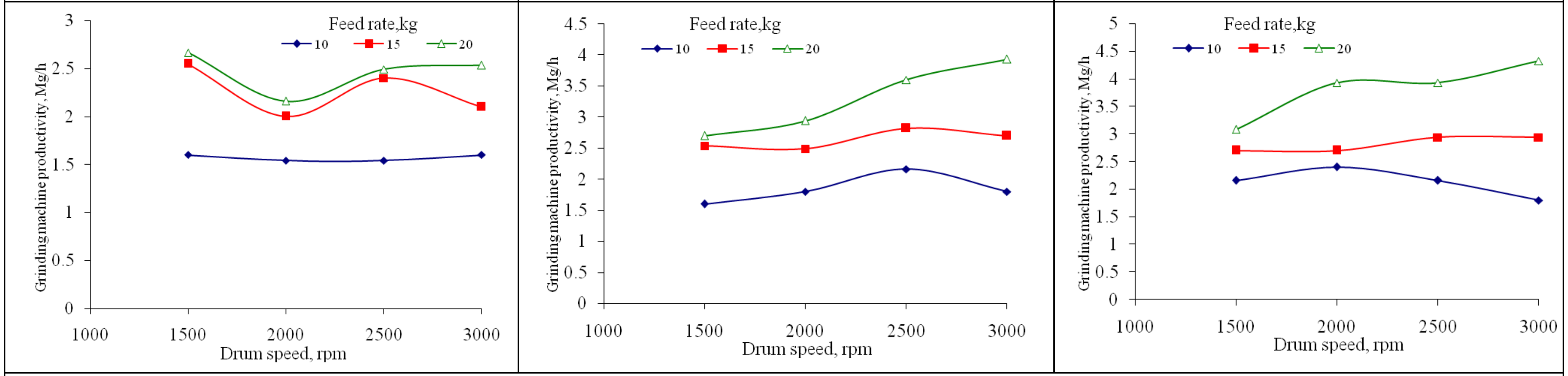

Fig. 10: Effect of drum speed on grinding machine productivity at different feeding quantity and knives number.

Feeding quantity "kg"; 10 | 15 | 20

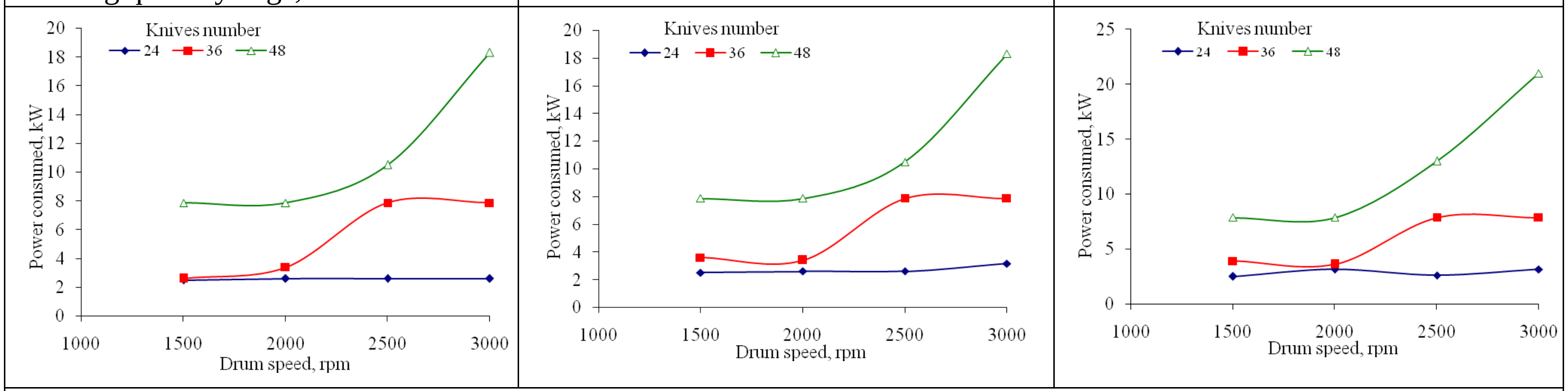

Fig. 11: Effect of drum speed on power consumed at different knives number and feeding quantity.

Using the multiple regression analysis the relation between the all levels of feeding quantity "F", drum speed "S", knives number "N" and the power consumed (P) can be shown as the following linear regression equation:

$$Pw = 0.00115\ F + 0.2324\ S - 0.2629N \qquad (R^2 = 0.8362)$$

The analysis of variance for the data of power consumed at different of feeding quantity, drum speed and knives number indicated a high significant between the treatments with (R^2 = 0.8362).

4- Effect of studied variables on specific energy requirement

Fig. (12) cleared that the effect of drum speed on specific energy requirement at different knives number and feeding quantity. From the figure it can be shows that the specific energy requirementhas has a directly proportional to feeding quantity and drum speed on the opposite that trend found at knives number. On the other side, the average of specific energy requirement increased from 2.04 to 3.99 kW.h/ton by increase the drum speed from 1500 to 3000 rpm, respectively. Moreover, the specific energy requirement decreased from 3.61 to 2.16 kW.h/ton by increase the knives number from 24 to 48, respectively. Then, the average of specific energy requirement increased from 1.23 to 3.52 kW.h/ton by increase the feeding quantity from 10 to 20 kg, respectively. Using the multiple regression analysis the relation between the all levels of feeding quantity "F", drum speed "S", knives number "N" and the specific energy requirement (E) can be shown as the following linear regression equation:

$$E = 0.0009\ F + 0.0955\ S - 0.1872\ N \qquad (R^2 = 0.8795)$$

The analysis of variance for the data of specific energy requirement at different of feeding quantity, drum speed and knives number indicated a high significant between the treatments with (R^2 = 0.8795).

Feeding quantity "kg"; 10	15	20

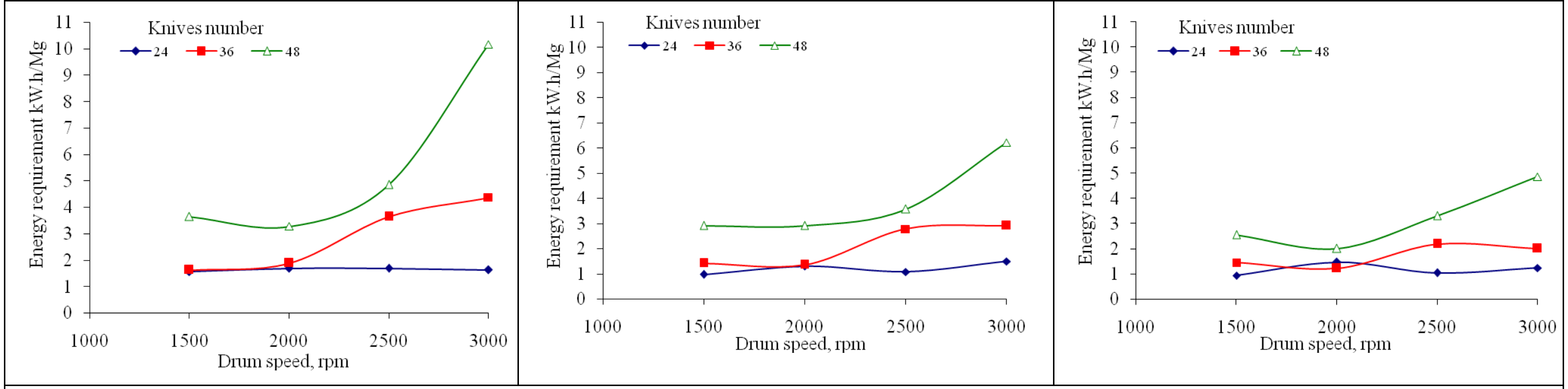

Fig. 12: Effect of drum speed on power consumed at different knives number and feeding quantity.

CONCLUSIONS

From the obtained results it can be concluded that:

1- The average of mango kernel ratio is about 74.5%. Then the mango kernel moisture content is about 12.0%. While the average main dimensions of mango kernel are 53.88±7.43, 20.42±3.21 and 10.98±1.89 mm at length, width and thickness, respectively. Also, the average of spherisity (75.5±20.39 %), geometric (4.1±1.25mm) and arithmetic (28.43±3.01 mm) diameters, surface area (56.9±34.3mm^2), coefficient of frictions on galvanized, iron black painted and iron sheet were about 0.649, 0.577 and 0.675 respectively, hardness (444.64±118.24N) and shear strength (224.62±98.65N).

2- The grinding machine can be manufactured and used to grinding the local mango kernel at the feeding quantity of 20 kg, drum speed of 2000 and knives number of 36 to obtain the homogeneous size distribution with less "CV" of 4.3, 11.22 and 12.26% respectively and at these studied parameters the MWD, machine productivity, power consumed and specific energy requirement are 1.309mm, 2.94Mg/h, 3.60kW and 1.22kW.h/Mg, respectively.

3- The developed grinding machine which manufacture from a locally materials can be tested to grind many solid wastes to increase the developed grinding machine reliability.

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الملخص العربى

تطوير اله جرش تناسب أنــوية بذور المانجو

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تعد عملية جرش المخلفات الزراعية من العمليات الأساسية الهامة التى يجب إتمامها لتوجيه المخلف إلى معظم الإستخدامات للإستفادة منه. والإهتمام بالمخلفات البستانية مثل أنوية بذور المانجو ودراسة مواصفات هذه الأنوية والمواصفات التشغيلية لألة جرشها هو هدف هذا البحث. حيث تهدف هذه الدراسة إلى تصميم اله جرش محليه الصنع تصلح لجرش انويه بذور المانجو.

وخلال هذه الدراسة تم قياس بعض خصائص أنوية بذور المانجو مثل نسبة النواه من البذرة وكانت حوالى ٧٤.٥% – الأبعاد الرئيسية للبذور (الطول – العرض – السمك)

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وكان متوسطها ٥٣.٨٨، ٢٠.٤٢، ١٠.٩٨ مم على التوالى – درجة الإستدارة (٧٥.٥%) ومتوسط القطر الهندسى (٤.١مم) ومتوسط القطر الحسابى (٢٨.٤٣مم) ومساحه السطح (٥٦.٩٠مم٢)، معامل الإحتكاك (مع الصاج المجلفن ٠.٦٤٩ ومع الصاج المطلى ٠.٥٧٧، ومع الصاج ٠.٦٧٥) ودرجة الصلابة (٤٤٤.٦٤ نيوتن) واجهاد القص (٢٢٤.٦٢ نيوتن). وذلك لإمكانية تحديد بعض الأبعاد التصميمية لألة الجرش والتى تم تصنيعها بورشة معهد بحوث الهندسة الزراعية وبعض الورش الخاصة وتم إجراء التجارب فى موسم

٢٠٠٩-٢٠١٠ حيث تم إختبار الآلة عند متغيرات:

١- كمية البذور ١٠، ١٥، ٢٠ كيلوجرام.

٢- سرعة عامود الإدارة ١٥٠٠، ٢٠٠٠، ٢٥٠٠، ٣٠٠٠ لفة/دقيقة (٢٨.٢٦، ٣٧.٦٨، ٤٧.١٠، ٦٥.٥٢ م/ث).

٣- عدد السكاكين ٢٤، ٣٦، ٤٨ سكين موزعه على ٨ مستويات.

وتم تقييم أداء الآلة بإختبار كل من جودة المنتج عن طريق تحديد توزيع أقطار الحبيبات ومتوسط القطر الموزون وكفاءة أداء الآلة بتحديد الإنتاجية والقدرة المستهلكة ومتطلبات الطاقة النوعية. وأوصت الدراسة بإمكانية إستخدام الآلة لجرش أنوية بذور المانجو عند كمية بذور ٢٠ كجم، سرعة ٢٠٠٠ لفة/دقيقة، ٣٦ سكين وذلك للحصول على أقل معامل إختلاف لتوزيع أقطار الحبيبات ذات القطر الأقل من ١.٤ مم والتى تعطى حوالى ١.٣٠٩ مم متوسط قطر موزون، ٢.٩٤ ميجاجرام/ساعة إنتاجية، ٣.٦٠ كيلووات قدرة مستهلكة، ١.٢٢ كيلووات ساعة/ميجاجرام متطلبات الطاقة النوعية. كما يوصى البحث بإمكانية إستخدام الآلة المصنعة محلياً وإختبارها لزيادة معدل إستخدامها مع مخلفات أخرى.