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Developing a Hammer Mill for Grinding Seashells

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ABSTRACT

This research aims to develop a reliable machine for grinding the seashells in order to be used as cheap source of calcium supplements in poultry feed formulations. The developed mill was fabricated locally in Egypt based on the theory of grinding hammers that included a special fabricated roughness hammer knives. It is powered by a 40 hp electrical motor that could be driven through merged inverter to control its speed and load. The performance of the developed mill was evaluated under three experimental variables including; three different drum speeds (S) of 26, 39 and 52 m/sec (1000, 1500 and 2000 rpm); three concave hole dia. levels of 5, 10 and 20 mm; and three feed rate levels of 20, 40 and 60 kg/min. The performance evaluation of the mill included four measuring parameters namely: the particle size distribution (fineness degree FD, %); the machine productivity (P), the consumed electrical energy (EC); and the machine operating costs (C)**.**The obtained results revealed that: the best fineness degree (FD), % could be achieved during setting the highest grinding speed of 52 m/sec (2000 rpm) at sieve diameter (D) 20 mm and feed rate (F) 60 kg/min, which produces the most needed diameters fits poultry supplements. However the optimum value of the machine productivity (P) was (3.30 ton/h) for the same setting .As well, the specific energy consumed (EC) was decreased from (15.93 to 5.08 kWh/ton) by increasing the drum speed from 26 to 52 m/sec and also increasing both feed rates from (20 to 60 kg/min)and sieve diameters from (5 to 20 mm) . Whereas, the minimum operating cost, (C) was (12.20 L.E/ton) by increasing the grinding drum speed to 52 m/sec for the inlet feeding rate of 40 kg/min and 20 mm sieve diameter.
Keywords: seashell, grinding .productivity, and consumed energy.

INTRODUCTION

The seashell is the common name for a hard, protective outer layer created by an animal that lives in the sea. The shell is part of the body of the animal. Empty seashells are often found washed up on beaches. The shells are empty because the animal soft parts has died or eaten by another animal. The seashells on a beach are very sharp, cutting and abrasive to bare-foot humans, and watercraft hulls (Ezekiel and Abowei 2013). Apart from the medicinal values and the usefulness of the seashell in the industry of fish products and other animals feed, seashell are used as poultry feed. Roland and Bryant (2000) reported that in order to form strong egg shells, chickens require a certain amount of calcium in their diets. The calcium supplements commonly used in poultry feeding are:- Limestone, crushed sea shells or sea-shell flour. The powder of these calcium supplements can be included at no more than 3 percent, because higher levels will lower feed intake. They indicated that the use of sea shell resulted in improved calcium retention, and better egg shell quality as measured by egg specific gravity, and several other criteria such as shell thickness, percent shell, etc.

Lynch and Rowland (2005) reported that the history of grinding began at the start of agriculture and outlines how size reduction developed over the centuries. Great technical achievements have led to the machines of today, which can grind solid particles at the rate of tens of thousands of tons per day. One certainty is the continuing need for size reduction to develop and fit the feed styles of livestock both today and in the future. El Shal, *et al.* (2010) indicated that the hammer mill is used almost exclusively in preparation of broiler rations because of its simplicity, ease to operate and low maintenance cost so, it had been widely spread in most of the poultry farms in Egypt, for this reason, such care had to be taken to develop and evaluate this type of mills for better utilization by several investigations to improve its performance.

Ekmay and Coon (2010) reported that the objects of grinding sea shell for poultry feed industries are to produce reliable fineness degree of in order to increase palatability, decrease surface reaction, and to facilitate mixing with other constituents of the feed ration. They denoted that calcium sources and particle sizes affect the egg shell quality and egg internal quality. They showed that the reliable fineness degree of grinding required for young chick 1.6 mm and for adult poultry 3.2 mm. Grinding is one of the energy-consuming processes in the human and animal feed industry. This process consumes from 70% up to 90% of total power requirements during the feed milling. The grinding energy consumption depends on the operation and geometrical parameters of the grinding machine and the reliable fineness degree (particle size distribution) of the milled material *(*Sokołowski, 1996).

In fact there are many factors that affecting the process of sea shell grind using a hammer mill such as drum speed, sieve hole sizes, feeding rate, kind of knifes, ….etc. However A series of documented studies have been arranged the effects of some grinding parameters on the hammer mill performance, and particle size distribution (fineness degree).These studies may be illustrated as follows:-

Reece *et al.*(1986) reported that, the grinding energy with hammer mill could be reduced by 35%, if mill screen size could be increased from 4.76 to 7.94 mm. Culpin (1986) showed that the power required for very fine grinding is much greater than for medium grade. For fine grinding, the power required for the burr mill was nearly three times more than that required for hammer mill. The objects of grinding grain for stock are to increase palatability, and to facilitate mixing with other gradients of the ration. Degree of grinding required for young chick 1.6 mm and for adult poultry 3.2 mm. Ali and Dimian (1988*)* indicated that the type of raw material, moisture content, fineness of grinding, rate of feed, type and condition of mill, are affecting the power requirement and milling capacity. They added that hammer mill reduces the size by impact, while burr (plate) mill reduces the size by crushing and shear forces. Vigneault, *et al* (1992) compared two hammers of different thickness (3.18 mm and 6.35 mm thick) in a commercial feed mill using the existing equipment. The comparison was based on the specific energy consumption and grinding rate. The results showed that a 13.6% saving in specific energy consumption and an increase of 11.1% in grinding rate can be obtained by using a thin hammer without affecting the quality of the ground material. However, the lifetime of the thin hammers was very low and difficult to predict. These thin hammers tended to fracture resulting in damage to the surrounding equipment.

Hassan (1994) found that increasing the screen size of hammer mill from 3.2 to 4.8 and 6.33 mm gave a decrease of 30 and 55% in grinding energy under operating conditions at drum speed 2930 rpm, no. of hammers 12 hammer and moisture content 5.1%. Increasing of drum speed from 1460 to 2930 and 3910 rpm gave a decrease of 59.1 and 67.9% in grinding energy under operating conditions at screen size of 6.35mm, no. of hammers 12 hammers and grain moisture content 5.4%.

El-Hadidi *et al.* (1997) compared three hammer mill types and showed that the consumed energy (kW.h/ton) was reduced 3.2 times by using burr mill compared with swinging beaters hammer mill and 1.5 times using rigid beaters and disintegrator hammer mills. No significant differences were found between mills with respect to fineness degree. Medium fineness degree of (3.0 - 4.2 mm) was increased using burr mill and disintegrator hammer mill compared with other types of mills. Hegazy *et al.* (2002) indicated that the MWD were 1.1205 1.152, 1.120 and 1 .090 for drum speeds of (1000, 1500, 2000, and 2500 r.p.m) respectively using sieve size of 2 mm. While the MWD were 1.795, 1.745, 1.653 and 1.601 respectively for the same four mentioned speed levels as using 3 mm sieve size. They showed that the hammer mill productivity increased gradually as the drum speed increase from 1000 to 2500 r.p.m, and decreased as sieve size was decreased from 3 to 2 mm. Increasing drum speed and decreasing sieves size caused a corresponding increase in the mill consumed energy. They added that grinding capacity decreased and grinding energy increased as fineness of grinding increased by decreasing screen size from 3 mm to 2 mm. *Egela et al. (2003)* studied the effect of the operational parameters on the fineness of the ground corn. The screen opening size was the most significant factor affecting on the fineness degree of the ground corn fineness. They concluded that the screen opening size of 14 mm, number of hammers of 45 and the drum speed of 28.6 m/s resulted in medium ground corn fineness.

Yang, et.al *(2006)* developed a numerical model based on the discrete element method (DEM) in a lab mill (simulate the IsaMill). They investigated the effects of parameters relating to particle material (i.e., sliding friction coefficient and damping coefficient) and operational conditions (i.e., rotation speed and solid loading) on the flow velocity, compressive force and power draw of the grinding mill. They indicated that the studied parameters had strong effects on the flow properties. They showed that increasing the sliding friction caused the flow velocity and compressive force to have minimum values due to the competitive mechanisms for energy transfer and dissipation, but increased the power draw.

Hirotaka *et al.* (2010) indicated that the uses a conical rotating drum which is sometimes employed in the granulation process. The conical rotating drum is half-filled with a mixture of two different sizes of spherical particles. They varied the rotational speed. Then they investigated the effect of the rotational speed on the axial segregation pattern and observed the flow mode. Jayasundara *et al.* (2012) studied the effect of grinding medium size on the wet milling performance in stirred mills using a combined numerical and experimental approach. They performed Physical experiments in a 1.4L stirred mill with the discs rotating at different speeds to grind aluminum hydroxide powders with different sized glass beads. The results showed that the grinding process followed the first order kinetics and the grinding rate increased with increasing disc speeds. *Dabbour et al (2015)* evaluated the grinding process of corn for feed, using a hammer mill prototype. They indicated that the mill performance, specific energy consumption, energy density, grinding index and grinding ability index were ranged from 0.70- 6.83 Mg/h, 3.38- 32.72 kJ/kg, 1.99- 18.82 MJ/m^3, 12.35- 91.28 $kJ.mm^{0.5}/kg$,and 0.81- 6.00 kJ/m^2 respectively. They added that the mean weight diameter, size reduction, bulk density and grinding effectiveness were ranged from 1.47- 2.89 mm, 2.60- 5.10 times, 524.58- 621.34 kg/m^3 and 8.88- 14.40 respectively at different sieve hole diameter and grain moisture content.

Knowledge of the optimum parameters affecting the performance of sea shell grinding machine is essential to develop and adjust the correct parameters of grinding and sieving machines. Therefore the objectives of the present study are to (1) Develop and locally fabricate a reliable mill for grinding the seashells in order to be used as cheap source of calcium supplements in poultry feed formulations. (2) Evaluate the performance of the developed mill versus different operational parameters in terms of the particle size distribution (fineness degree, %); the developed mill productivity; and its electrical energy consumption. (3) Estimate the developed mill operational cost.

MATERIALS AND METHODS

The pre-developed grinding machine was a fixed beaters hammer mill and was used mainly to mill the treated seashell. The machine was locally fabricated to grind various types of solid grains such as corn. Thereby, it was modified to suit grinding of the hard loads such as sea shells. The materials used in the present study may be summarized as follows:-

The developed sea shells grinding machine

The main specifications of the developed hammer mill are listed in Table (1), while, its schematic drawing is shown Fig. (1)

Table 1. Main specifications of the developed hammer mill.

Items	Specifications
- Made;	Egypt
- Hammers No.	6
- Power source;	three phase electric motor
- Motor power, HP (kW);	40 (29.828)
- Operating speed, r.p.m.	1000, 1500 and 2000
- Overall length, mm;	2100
- Overall width, mm;	1320
- Overall height, mm;	2490

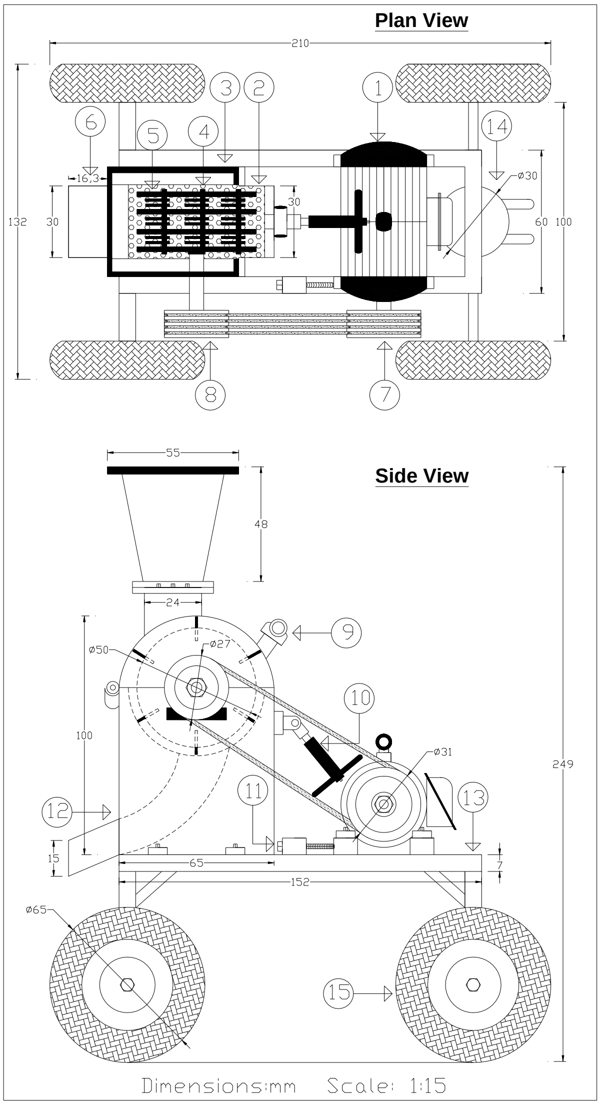

Fig. 1. The schematic drawing of the developed sea shells grinding machine

(1-electrical motor, 2- concave, 3- hopper, 4- drum, 5- knives,6- outlet gate,7- motor pulley 31 cm Dia.,8- drum pulley 27 cm Dia., 9-air vent, 10- hopper tension, 11- motor tension, 12-mill grinding body, 13- chassis, 14- machine draw bar and 15-machine wheels 65 cm Dia.)

As shown in Table (1) and Figs. (1 and 2), the developed grinding machine is constructed from the following modified parts:

1-Power source: as shown in Fig. (3) a three phase 40 hp electrical motor was used to operate of the movable parts of the developed sea shells mill. The motor speed could be changed electronically by changing the inlet current frequency using electronic inverter as shown in Fig. (5) The motor pulley was of 31 cm dia. and had 4 V shape belts (20 mm width and 1250 mm length).

2- The grinding body: which included the following parts:

A- The feeding hopper: the used feeding hopper has a square inlet open with dimensions of 55 ×55 cm square hole, while the hopper height is 48 cm, as shown in (Fig.1, No.3)

B- The milling drum: the specifications of the developed milling drum are listed in Table (2), while, its photography view is shown in Fig. (4) The driven drum pulley was of 27 cm dia. The drum was equipped with No. of 8 roughness flails/row .These rough hammer knives were fabricated from a special carbonated metals to sustain grinding friction loads.

C- The milling concave: the experimental work deduced three different holes diameters on the grinding concaves. Hence three grinding concaves were fabricated from special stainless steel to reduce the corrosion. These grinding concaves were designed with holes diameters of (5, 10 and 20 mm). Each tested grinding concave was positioned under the grinding drum to correspond the tested treatment as shown in (Fig.1, No.2)

D- The outlet gate: it was made with dimensions of (15× 30 cm). It was installed at a height of 60 cm from the ground to for packing the grinding sea shells, as shown in (Fig. 1, No. 6).

3-The machine chassis: it was made from 7 cm beams and had 132 cm width and 210 cm length. The chassis was mounted on 4 wheels each with 65 cm dia. the chassis could be trailed frontally by a tractor from the inlet formed draw bar (Fig.1 , No.14).

Fig. 2. The mill grinding machine

Fig.3.The electrical motor.

Fig. 4. The milling drum

Fig. 5. The used inverter.

Table 2. specifications of the milling drum.

Type of beaters	Flails
Diameter, cm	50
Width, cm	40
No. of rows	6
No. of flails/row	8
Flail dimensions, cm	15 long x 5 wide x 1 thickness,

The seashells samples

The tested seashells samples were picked up, collected and cleaned. The tested samples were basically found in off-white and pale pinkish tones followed by other colors like orange, brown, white and black as shown in Fig. (6) The seashell after milling is shown in Fig. (7).

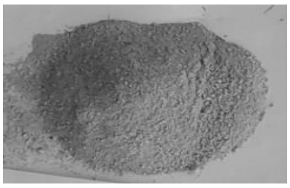

Fig. 6. seashell befor milling. Fig. 7. seashell after milling.

Experimental procedure

The experiments were carried out at *Refaay village-El-Gamalia region, Dakhlia Governorate*. All experimental treatment were carried out at different combinations of drum speeds, grinding screen openings diameters and seashells feed rates to determine the particle size distribution (Fineness degree) (FD) %, the machine productivity, the energy requirements and the economic cost for milling the seashells. The experiments were replicated three times. The data were statistically analyzed to determine the significant effect of the mentioned variables under the study according to the probability ($P < 0.05$) by the CoStat Program (Oida, 1997).

Experimental Treatments

a) Drum speed (26, 39 and 52 m/sec) (1000, 1500 and 2000 rpm),
b) Grinding sieve diameters (5, 10 and 20 mm),
c) Seashells feed rate (20, 40 and 60 kg/min).

Measurements

Evaluation of the developed mill hammer mill for grinding seashells was performed in terms of the following measuring parameters:

1- Fineness degree FD, %:

The ground seashells samples were classified into four categories according to Henderson and Hansen (1968). The seashells granulation and sieve analysis were determined using a laboratory automatic sieve shaker (PaSakha Teraoka – type SNF-7 Japan made) as follows: After milling all sample, a 250 grams of milled sample was placed on the top of sieves and the shaker was run for 5 minutes, using a sieve series of 0.7, 1.4, and 2 mm round holes respectively. After each test period the percentage of through and over tails were recorded. The FD, % was determined using the following equation

$$F.D = \frac{\Sigma_i^n .X_i .W_i}{W_{i-n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where: F.D: the seashell fineness degree, %.
X_i : the mean dia. of each division, mm.
W_i : the sample weight of each division, g.

2 - Machine productivity, P (ton/h):

The developed mill productivity was determined for each investigated treament by dividingthe product mass on the time consumed in. The productivity was calculated using the following formula:

Machine productivity (ton/h) = M_w / t ………… (2)

Where: M_w=milled weight, ton; t = the time consumed in operation, h.

3 – Specific energy consumption, EC (kW.h/ton)

The electrical energy consumption (kW) was determined for each test by taking the readings of both line current and voltage, using super clamp meter (700-k type) that connected to the hammer mill motor starter. Hence the consumed electrical power (kW) for each treatment was estimated according to (*Kurt, 1979*) as follow:

$$Ep = {}^{3}\sqrt{\ } *I*V*\eta*\cos\varphi/1000 \quad \ldots\ldots\ldots\ldots(3)$$

Where: EP = electrical consumed power under different machine loads;
I = line current strength in Amperes;
V = potential difference (voltage) being equal to 380 V;
η = mechanical efficiency (assumed as 80 %);
cos φ = power factor (was taken as 0.7).

Consequently, the specific energy consumption (kWh/ton) for each treatment could be calculated using the following equation:

Specific energy consumption = consumed power (kW.h) / Machine productivity (ton/h).

4-The cost estimation(L.E/ton):

To determine the cost of mechanized the processes of grinding seashells by using the developed machine, the following equation was used **(**Awady *et al.*, 2003):

$$C = \frac{P}{h}\left[\frac{1}{a} + \frac{I}{2} + T + r\right] + (W.e) + \frac{m}{144} \quad \ldots\ldots\ldots (4)$$

Where :C: hourly cost, L.E./h; P: price of the machine, L.E.;
h: yearly working hours, h/year;
a: life expectancy of the machine, year;
I: interest rate per year; T: tax overheads ratio;
r: repair and maintenance ratio; W: power of motor, kW;
e: hourly cost/kW.h. m: the monthly average wage , L.E.; 144: the monthly average working hours.

The operating cost was determined using the following formula:

$$Operating\ cost(L.E/ton) = \frac{Machine\ \text{hourly cost,(L.E./h)}}{Actual\ \text{milling}\ capacity(ton/h)} \quad (5)$$

RESULTS AND DISCUSSION

The developed mill was evaluated by studying the effects of the studied machine parameters on each of: - the particle size distribution of the ground sea shells product (fineness degree %); the machine productivity (ton/h);the specific energy consumption (kW.h/ton). In addition the developed mill operational cost was estimated (L.E/ton).

A- The fineness degree (FD, %):

Results presented in Fig. (8) showed the relationships between drum speed (S) and the fineness degree FD, %, at different sieve diameters (D). Increasing the (S) increased the FD, % for sea shell powder granules {(>1) and from (2-3) mm} with increasing the treatment of the (D) in direct relationships but this relationships differs vice versa with sea shell powder granules FD, % {(2-3) and from (<3) mm} in opposite relationships by increasing the (S) the FD, % decreased .However, the optimum values of the FD, % categories {(>1), (1-2), (2-3) and (<3mm)} were (35.50, 47.80, 29.07 and 46.90 %) respectively at for (S) 52 m/sec and 5mm of (D) for the first two percentages and (S) 26 m/sec and 20 mm of (D) for the second two percentages. The minimum values of FD, % percentages {(>1), (1-2), (2-3) and (<3mm)}were (8.40, 15.63, 5.27 and 11.43 %) respectively at for (S) 26 m/sec and 20 mm of (D) for the first two percentages and (S) 52 m/sec and 5 mm of (D) for the second two percentages. These results may be attributed to increasing the drum speed, which increased the ability of milling the sea shells granules {(>1) and from (2-3) mm} at the lower speeds that mix more time than{(2-3) and from (<3) mm} granules which lasts less time than the first one however the sieves diameters (10 and 20 mm) at the high drum speeds produces bigger granules of sea shell particles.

Data illustrated in Fig. (9) showed the relationships between drum speed (S) and the FD percentages, at different feed rates (F). Increasing the (S) increased the FD, % for sea shell powder granules {(>1) and from (2-3) mm} with increasing the treatment of the (F) in direct relationships but this relationships was oppositely with sea shell powder granules FD, % {(2-3) and from (<3) mm} by increasing the (S) the FD, % decreased .However, the optimum values of the FD, % {(>1), (1-2), (2-3) and (<3mm)}were (34.80, 44.37, 28.23 and 44.33 %) respectively at for (S) 52 m/sec and 60 kg/min of (F) for the first two percentages and (S) 26 m/sec and 20 kg/min of (F) for the second two percentages. The minimum values of FD, % percentages {(>1), (1-2), (2-3) and (<3mm)} were (11.27, 16.17, 6.00 and 14.83%) respectively at for (S) 26 m/sec and 20 kg/min of (F) for the first two percentages and (S) 52 m/sec and 60 kg/min of (F) for the second two percentages. These results because of; by increasing the drum speed the feed rate increases also which increased the ability of milling the seashells granules {(>1) and from (2-3) mm} at the lower speeds that mix more time than {(2-3) and from (<3) mm} granules which lasts less time than the first one however the sieves diameters (10 and 20 mm) at the high drum speeds produces bigger granules of seashell particles.

Statistically, there is high significance difference between the tested factors of the FD, %. Also, the total interaction between different treatments show a high significant effect ($P<0.05$) and (C.V= 0.419, 0.309, 0.624 and 1.077) for the FD,%{(>1), (1-2), (2-3) and (<3mm)} respectively. ANOVA analysis indicated highly significant differences between the treatments. A simple power regression analysis applied to relate the change in FD, % with the change in the tested factors for all treatments. The obtained regression equations were in the form of:

FD, %[(>1)mm] =6.983 +0.415 S -1.118D+0.3439 F (R^2= 0.9482)
FD, % [(1-2)mm] = 11.317+0.585 S-1.268D +0.325 F(R^2= 0.9375)
FD, % [(2-3)mm] = 32.994- 0.405 S+0.909 D-0.295 F(R^2= 0.9615)
FD, % [(<3)mm]= 48.706- 0.595 S+1.477 D- 0.374 F (R^2= 0.9381)

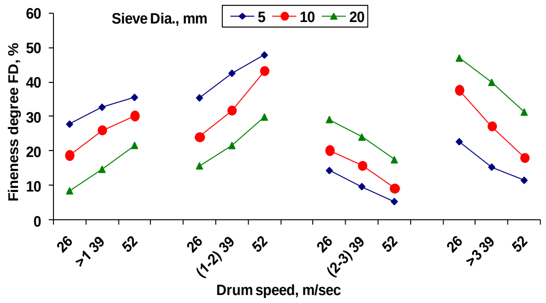

Fig.8: Effect of the drum speed on the fineness degree at the different sieve diameters.

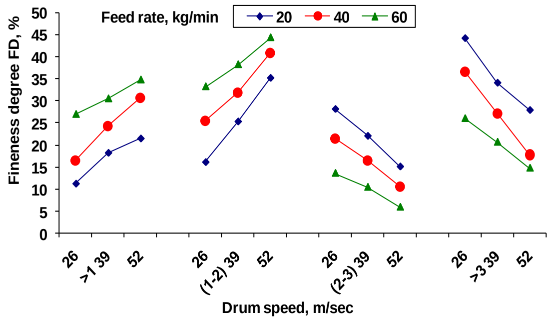

Fig.9: Effect of the drum speed on the fineness degree at the different feed rates.

Also, Fig (10) shows the relationships between sieve diameters (D) and the FD %, at different feed rates (F).

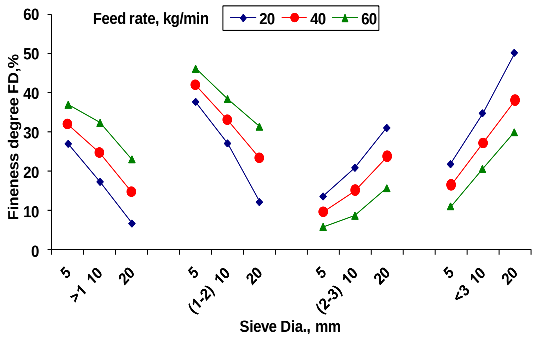

Fig.10. Effect of the sieve diameters on the fineness degree at the different feed rates.

Increasing the (D) increased the FD, % for sea shell powder granules {(2-3) and from (<3) mm} with increasing the treatment of the (F) in direct relationships but this relationships was oppositely with sea shell powder granules FD, % {(>1) and from 1-2) mm} by increasing the (D) the FD, % decreased .However, the optimum values of the FD, % {(>1), (1-2), (2-3) and (<3mm)}were (36.97, 46.13, 31.0 and 50.03 %) respectively at for (D) 5 mm and 60 kg/min of (F) for the first two percentages and (D) 20 mm and 20 kg/min of (F) for the second two percentages. The minimum values of FD, % percentages {(>1), (1-2), (2-3) and (<3mm)}were (6.77, 12.20, 5.83 and 11.07 %) respectively at for (D) 20 mm and 20 kg/min of (F) for the first two percentages and (D) 5 mm and 60 kg/min of (F) for the second two percentages. These results because of by increasing the sieve diameters also, the feed rate should be increased which increases the ability of milling the sea shells granules {(2-3) and from (<3) mm } at the lower speeds that mix more time than {(>1) and from (1-2) mm} granules which lasts less time than the first one.

B- The machine productivity (P, ton/h):

Results showed in Figs. (11 and 12) showed the relationships between drum speed (S) and the machine productivity (P, ton/h), at different sieve diameters (D) and different feed rates (F). Increasing the (S) increased the P with increasing the treatments of both the (D and F) in a direct relationships .Where; the maximum values of the P were (2.31 and 3.43 ton/h) respectively at (S) 52 m/sec for 20 mm of (D) and 60 kg/min for (F). The minimum values of P were (1.65 and 1.01 ton/h) respectively at (S) 26 m/sec for 5 mm of (D) and 20 kg/min for (F). These results may be attributed to; by increasing the drum speed the outlet mass of sea shells increases relatively that increases the productivity in the unit of operational time.

Also, data showed in Fig. (13) showed the relationship between sieve diameter (D) and the machine productivity (P, ton/h), at different feed rates (F) . Increasing the (D) increased the P with increasing the treatments of (F) in a direct relationship .Besides, the highest value of the P was (3.30 ton/h) at (D) 20 mm and 60 kg/min for (F). The lowest value of P was (1.05 ton/h) at (D) 5 mm for (D) and 20 kg/min for (F). These results owing to; by increasing the sieve diameters the inlet feed rate increases relatively to maximize the machine productivity.

Statistically, there is high significance difference between the tested factors of the P. Also, the total interaction between different treatments show a high significant effect ($P<0.05$) and (C.V= 0.20) for the P. ANOVA analysis indicated highly significant differences between the treatments. A simple power regression analysis applied to relate the change in P with the change in the tested factors for all treatments. The obtained regression equation was in the form of:

[P, ton/h] =-0.731+ 0.0138 S + 0.0113 D + 0.0544 F (R2= 0.9539)

C- The electrical consumed energy (EC, kW.h/ton):

Commonly results showed in Figs. (14 and 15) showed the relationships between drum speed (S) and the consumed electrical energy (EC, kW.h/ton), at different sieve diameters (D) and different feed rates (F). Increasing the (S) decreased the EC with increasing the treatments of both the (D and F) in opposite relationships .While, the maximum values of the EC were (13.43 and 16.47 kW.h/ton) respectively at (S) 26 m/sec for 5 mm of (D) and 20 kg/min for (F). The minimum values of EC were (8.87 and 4.87 kW.h/ton) respectively at (S) 52 m/sec for 20 mm of (D) and 60 kg/min for (F). These results could be attributed to; by increasing the drum speed the consumed energy decreases relatively.

Too, Fig. (16) showed the relationship between sieve diameter (D) and the consumed energy (EC, ton/h), at different feed rates (F) . Increasing the (D) decreased the EC with increasing the treatments of (F) in opposite relationship .Generally, the highest value of the EC was (15.93 kW.h/ton) at (D) 5 mm and 20 kg/min for (F). The minimum value of EC was (5.08 kW.h/ton) at (D) 20 mm for (D) and 60 kg/min for (F). These results owing to; by increasing the sieve diameters the consumed energy decreased relatively to minimize the EC. Statistically, there is high significance difference between the tested factors of the EC. Also, the total interaction between different treatments show a high significant effect ($P<0.05$) and (C.V= 0.328) for the EC. ANOVA analysis indicated highly significant differences between the treatments. A simple power regression analysis applied to relate the change in EC with the change in the tested factors for all treatments. The obtained regression equation was in the form of:

[EC, kw.h/ton] = 24.518- 0.082 S- 0.0821 D- 0.262 F (R2= 0.8555)

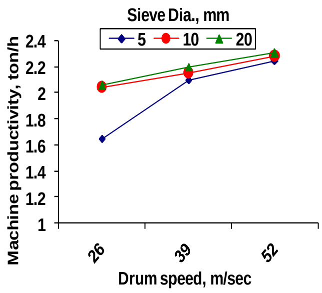

Fig.11: Effect of the drum speed on the machine productivity at the different sieve diameters.

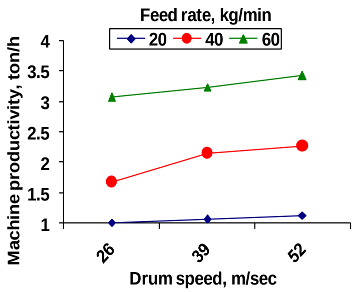

Fig.12: Effect of the drum speed on the machine productivity at the different feed rates.

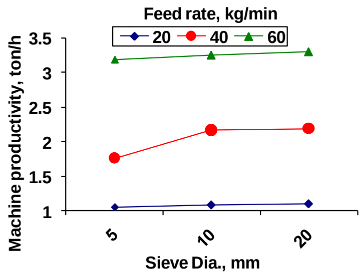

Fig.13: Effect of the sieve diameters on the machine productivity at the different feed rates.

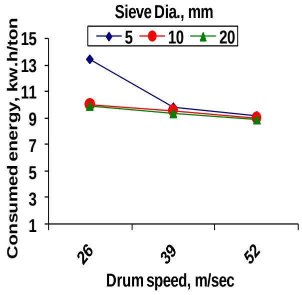

Fig.14.Effect of the drum speed on the consumed energy at the different sieve diameters.

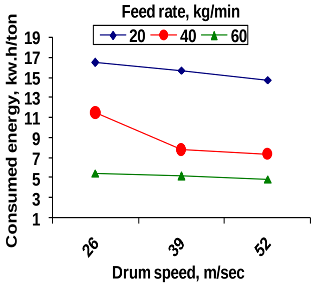

Fig.15. Effect of the drum speed on the consumed energy at the different feed rates.

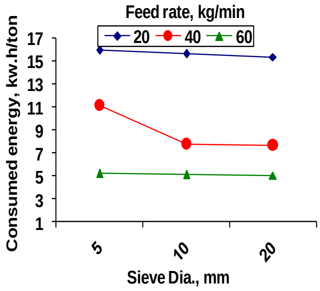

Fig.16. Effect of the sieve diameters on the consumed energy at the different feed rates.

D- The machine operating cost (C, L.E/ton):

Results presented in Figs. (17 and 18) showed the relationships between drum speed (S) and the machine hourly operating cost (L.E/ton), at different sieve diameters (D) and different feed rates (F). Increasing the (S) decreased the C with increasing the treatments of both the (D and F) in opposite relationships .Where, the highest values of the C were (24.07 and 26.56 L.E/ton) respectively at (S) 26 m/sec for 5 mm of (D) and 20 kg/min for (F). The minimum values of C were (13.99 and 11.70 L.E/ton) respectively at (S) 52 m/sec for 20 mm of (D) and 40 kg/min for (F). These results may be attributed to; by increasing the drum speed the operating cost decreased relatively.

Finally, data showed in Fig. (19) showed the relationship between sieve diameter (D) and the machine operating cost (C, L.E/ton), at different feed rates (F). Increasing the (D) decreased the (C) with increasing the treatments of (F) in opposite relationship .Besides, the optimum value of the C was (25.72 L.E/ton) at (D) 5 mm and 20 kg/min for (F). The lowest value of C was (12.20 L.E/ton) at (D) 20 mm for (D) and 40 kg/min for (F). These results owing to; by increasing the sieve diameters the inlet feed rate increases relatively to minimize the machine operating cost. Statistically, there is high significance difference between the tested factors of the C. Also, the total interaction between different treatments show a high significant effect ($P<0.05$) and (C.V= 0.238) for the C. ANOVA analysis indicated highly significant differences between the treatments. A simple power regression analysis applied to relate the change in C with the change in the tested factors for all treatments. The obtained regression equation was in the form of:

[C, L.E/ton] = 35.653- 0.1718 S- 0.1916 D - 0.231 F (R^2= 0.9997)

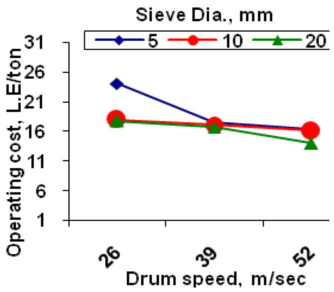

Fig.17. Effect of the drum speed on the operating cost at the different sieve diameters.

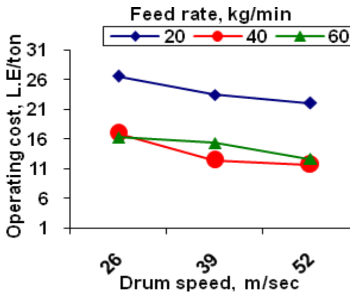

Fig.18.Effect of the drum speed on operating cost at the different feed rates.

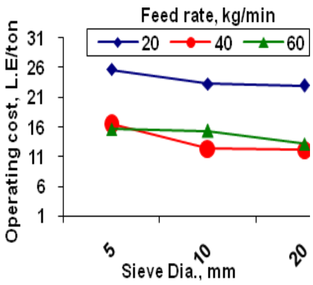

Fig.19.Effect of the sieve diameters on the operating cost at the different feed rates.

CONCLUSION

The main aim of this study was to develop and fabricate a reliable mill for grinding the seashells in order to be used as calcium supplements in poultry feed formulations. In addition to investigate the effects of grinding machine parameters on the machine productivity, machine energy consumption, and fineness degree of the milled seashells samples.

The gained results could be summarized as follows:

1- The best fineness degree (FD), % could be achieved during setting the highest grinding speed of 52 m/sec (2000 rpm) at sieve diameter (D) 20 mm and feed rate (F) 60 kg/min, which produces the most needed diameters fits poultry supplements.

2- The highest machine productivity value (3.30 ton/h) was obtained at sieve diameter of 20 mm, feed rate of 60 kg/min, and drum speed of 52 m/sec.

3- The highest specific energy consumption value (15.93kW.h/ton) was accomplished sieve diameter of 5 mm, feed rate of 20 kg/min, and drum speed of 26 m/sec.

4- The reliable the machine operating costs value (12.20 L.E/ton) was estimated by using sieve diameter of 20 mm and feed rate of 40 kg/min and drum speed of 52 m/sec.

REFERENCES

Ali, L.H.M. and T.F. Dimian, (1988). Equipment of animal production mechanization. Baghdad Univ. Iraq in Arabic: 231-249.

Awady, M. N.; I. Yehia, M. T. Ebaid and E.M. Arif. (2003). Development and theory of rice cleaner for reduced impurities and losses. Misr J. Ag. Eng., 20 (4): 53-68.

Culpin, C., (1986). Farm Machinery-The English Language. Book Society. Collins (11th ed.): 276-285.

Dabbour, M.I., A. Bahnasawy, S. Ali, and El- Z. Haddad. (2015) Grinding Parameters and their Effects on the Quality of Corn for Feed Processing. J.Food Process Technol 6: 482.

Egela. M.I.; Y.F. Sharobeem and M.E. Badawy, (2003). Modification of some operational parameters for local manufactured hammer mill. The 11th annual conference of Misr Society of Ag. Eng.

Ekmay R.D. and C. N. Coon (2010). The effect of limestone particle size on the performance of three broiler breeder purelines. Int. J. Poult Sci.; 9(11):8–1042.

El-Hadidi ,Y.M.;E.E.A. Amin and K.E.S. Hegazy, (1997). Performance evaluation for some types of crushing machines used in poultry farms. Misr J.Ag.Eng., 14(3):285-298.

Ezekiel, E. N. and J. F. N. Abowei, (2013). Length-weight relationship and condition factor of Heterotis niloticus from Amassoma Flood plain, Niger Delta, Nigeria. Appi. Sci. Reports, 4 (1): 164-172.

Hassan, M.A., (1994). Modifying and evaluating a small locally made mix-milling unit suitable for Egyptian poultry farms. Misr. J. Ag. Eng., 11(2) : 269-584.

Hegazy, K. E. S. ; A. O. Al-Ashhab, M. M. A. Mosa, and B. A. Hemeda, (2002).Preparation and Conversion of Eggshell As Hatchery By-Product Wastes to Produce Untraditional Poultry feeds., Misr. J. Ag. Eng., 19(4): 958-972.

Henderson, S.M., and P.L. Hansen, (1968). Hammer mill and Burr mill performance analyzed . Trans. Of the ASAE., 11 (3): 399-402.

Hirotaka Y.; K. Toshihiro, and T. Toshitsugu, (2010). Relation between segregation patterns and granular flow modes in conical rotating drum. Flow Measurement and Instrumentation: 21, 3, 207–211.

Jayasundara, C. T., R. Y. Yang, and A. B. YU, (2012). Effect of the size of media on grinding performance in stirred mill. Minerals Engineering: 33, 66–71.

Lynch A. J. and C. A. Rowland, (2005). The History of Grinding. SME, ISBN: - 0873352386, 9780873352383

Oida, A. (1997). Using personal computer for agricultural machinery management. Kyoto University. Japan. JICA publishing.

Reece ,R.N.; B.D, Lott and J.W, Deaton,(1986). The effects of hammer mill screen size on ground corn particle size,pellet durability, and broiler performance. Poult. Sci., 65:1257-1261.

Roland D.A. and M. Bryant, (2000). Nutrition and feeding for optimum egg shell quality. Proc. The XXI world's Poultry Congress; Montreal, Canada

Sokołowski, M. (1996). Energy consumed in grinding–a new idea of a general law of comminution–new tests stands and testing results. Recents Progress en Genie Proceeds, 10: 221–226.

Vigneault, C, T.M. Roihwell, and G. Bourgeois, (1992). Hammer mill grinding rate and energy requirements for thin and conventional hammers. Can. Agric. Eng. 34(2):203-206.

Yang. R. Y.; C.T. Jayasundaraa, A.B. Yua, , and D. Curry, (2006). DEM simulation of the flow of grinding media in IsaMill. Minerals Engineering,: 19, (10), 984–994.

تطوير مجرشة لطحن الصدف البحري

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توجد الأصداف البحرية مجروفة على شواطئ البحار بكثرة بسبب الأمواج، وتكون فارغة حيث يكون الحيوان الذي بداخلها قد مات وتحلل جسمه أو التهم من قبل الكائنات الأخرى.وقد أشارت الأبحاث السابقة إلى أن الأصداف تعتبر من مكملات التغذية في علائق الدواجن حيث تعتبر مصدر غني بمحتواه من الكالسيوم الذي تحتاجه الدواجن بشدة لتكوين قشور البيض. وبما أن الصدف البحري يوجد في صورة صلبة فكان من المهم طحنه لاستغلاله كمصدر للكالسيوم رخيص في علائق الدواجن بدلا من استخدام المركبات الأخرى عالية الثمن. وحيث أنه لا يفضل طحن الصدف إلى درجة النعومة العالية (البودر) حتى تكون هناك سهولة في عملية التغذية والهضم فقد اقترح تطوير آلة جرش الذرة المطرقية لأنها تقلل من النسب المئوية للجرش الناعم وتزيد النسب المئوية للجرش الوسط والخشن. لذلك كان الهدف من هذا البحث هو تطوير آلة جرش الذرة المطرقية لتناسب طحن هذه الأصداف ثم دراسة تأثير بعض عوامل الطحن الأساسية على أداء الآلة بعد التطوير.وتضمنت نقاط تطوير الآلة ما يلي: أولا:استخدام موتور ثلاثي الأوجه ذو قدرة كبيرة(40 حصان ميكانيكي) مزود بإمكانية التحكم في سرعته والحمل القائم به عن طريق انفرتر موصل به للتحكم في تردد شدة التيار وبالتالي التحكم في سرعة الموتور دون التأثير علي الحمل مع إمكانية فرملة الموتور عند الحاجة.ثانيا:تصنيع مطارق عالية الصلادة موزعة علي درفيل الطحن والتي تتميز بمقاومتها للتآكل وعمرها الافتراضي الكبير. ثالثا:تصميم وتصنيع غرابيل الطحن من الاستانليس ذات فتحات لها أقطار مناسبة للصدف للحصول علي أقطار مناسبة لسهولة عملية الهضم. واشتملت متغيرات ومعاملات الدراسة على ما يلى: ثلاثة مستويات لسرعات الدرفيل: (26و 39و 52 متر/الثانية) (1000و 1500و 2000 لفة/الدقيقة) وثلاثة أقطار لفتحات غرابيل الطحن: (5، 10 و 20 مم) وثلاثة معدلات لتغذية للصدف: (20، 40 و 60 كجم/د). وتضمنت قياسات تقييم أداء المجرشة المطرقية المطورة المعايير الآتية: النسبة المئوية لدرجة النعومة للحبيبات المطحونة و الإنتاجية والطاقة المستهلكة للآلة والتكلفة الاقتصادية.وأشارت النتائج المتحصل عليها إلى ما يلي: (أولا): كانت أحسن درجات نعومة لمتوسطات أقطار الحبيبات والتي تناسب علائق الدواجن تم الحصول عليها بضبط الآلة عند سرعة درفيل 52 متر/الثانية و قطر غربال 5 مم ومعدل تغذية 60 كجم/الدقيقة. (ثانيا): كانت أعلي إنتاجية للآلة 3.30 طن/الساعة عند سرعة درفيل 52 متر/الثانية و قطر غربال 20 مم ومعدل تغذية 60 كجم/الدقيقة. (ثالثا): كان أعلي استهلاك للطاقة 15.93 كيلوات ساعة/الطن عند سرعة درفيل 26 متر/الثانية و قطر غربال 5 مم ومعدل تغذية 20 كجم/الدقيقة. (رابعا): كانت أقل تكلفة تشغيل 12.20 جنيه/الطن عند سرعة درفيل 52 متر/الثانية و قطر غربال 20 مم ومعدل تغذية 40 كجم/الدقيقة. لذلك نوصي باستخدام الآلة المطورة علي المستوي المحلي لتوفير مكون أساسي من مكونات العلائق الداجنة بأرخص الطرق.