MANUFACTURE AND EVALUATION A COMPATIBLE UNIT TO PRODUCE ANIMAL FEED PELLETS

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Abstract

The main objective of this, research was to manufacture and evaluate compatable unit to produce a rabbit feed pellets including mixing and pelleting the formula in one step. The optimum results of this unit were 427.87 kg/h production rate , 37.96kW.h/ton energy, requirements , 88.29% mixing efficiency , 0.671gm /cm3 bulk density , 93.21% pellet durability , 49.01N hardiness, and 566.36 die L/D ratio of 5.5:1, 3.5 min of mixing retention time, and rollers teeth width of 10 mm and LE/ton cost using residues formulation including black seed meal.

INTRODUCTION

Rabbit production has potential in developing countries as a mean of supplying cheap high quality animal protein within the shortest possible time.

Animal fead production always care about, pellet quality, the profited of product and mixing and peleting process, balk density, dirability and hardness.

Agricultural residues represent an extreme problem in Egypt facing the people and the state from economic, environmental and healthy aspects and also arable area of generate annually amount of crop residues almost 25-35 million tons, in addition 293 million cubic meter of animal wastes, this amount is consistently increasing yearly, (Ismael 2001).

David (2003) found that a specific rows of die holes, such as the two interior and outside rows, also sometimes are counter bored to greater depths to encourage feed flow through these outer rows of holes to help dies did not wear more evenly. Hasting (2003) limited the operating conditions which effect on the quality of pellets feed as follows: pellet die thickness as related to diameter of hole as factor in pelleted quality, speed of ration should be also considered for each die thickens/hole diameter combination. Mcmullen *et. al.*, (2004) used a laboratory pellet mill to produce pellets from poultry litter. Due to the high mineral content of poultry litter, samples were mixed with 3% vegetable oil to lubricate the die and to ensure that the pellet die will

not clog during pelleting. Before passing through the pellet die, the temperature of the litter was increased to 75ºC by injecting steam and by the use of a heat gun that blew hot air through the litter. Due to frictional heating during pelleting through the 3/16 (4.76 mm) diameter holes die, the temperature of the pellets exiting the die increased to 85ºC ± 2ºC. after pelleting, the pellets were cooled in an environmental chamber set at 22ºC and 40% relative humidity.

Lee *et. al.* (2005) illustrated that the die design parameters are the length, width, and height. The heat transfer analysis between the cooling die and product is valuable for die design and prediction of product temperature at analog quality during process scale-up. Predicted product temperatures were generally within 68°C of the measured values depending on the size of the cooling die, the feed moisture content, and the cooling method. Kaddour *et. al.* (2006) found that geometrical dimensions of die holes reference is the most important factor influencing extruder machine efficiency and pellets quality. Producing 12mm diameter high quality of large animal feed pellets rely the ration components attributes, for that, the high quality extruded pellets made from residues need different die hole specification comparing with that made from standard components. Results show that the optimum machine efficiency appraised by machine productivity, energy requirements and total losses and appraised for pellets quality .

The objectives of this study are to manufacture and evaluation of a compatible unit to produce rabbit feed pellets from black seed meal residue and optimizing operating parameters (retention time, L / D ratio. Roller speed and rollers teath.

MATERIALS AND METHODS

The experiments were carried out during years 2011and 2012. The compatible unit to produce rabbit feed pellets was manufactured at privet workshop in Zagazig city and evaluated in agriculture engineering research institute workshop in the Cairo.

MATERIALS:

Composition of the experimental ration:

A rabbit experimental ration was used in the present study, it has the following composition as shown in Table 3:

Table 3. The composition of residues and stander rabbit rations .

Standard formula

Ingredients	Percentage (%)
Barley grains	19.20
Wheat bran	28.50
Clover hay	30.90
Soybean meal	5.00
Corn grain	11.7
Molasses	3.00
Limestone	1.00
Sodium chloride	0.25
Premix	0.30
DL Methionine	0.15

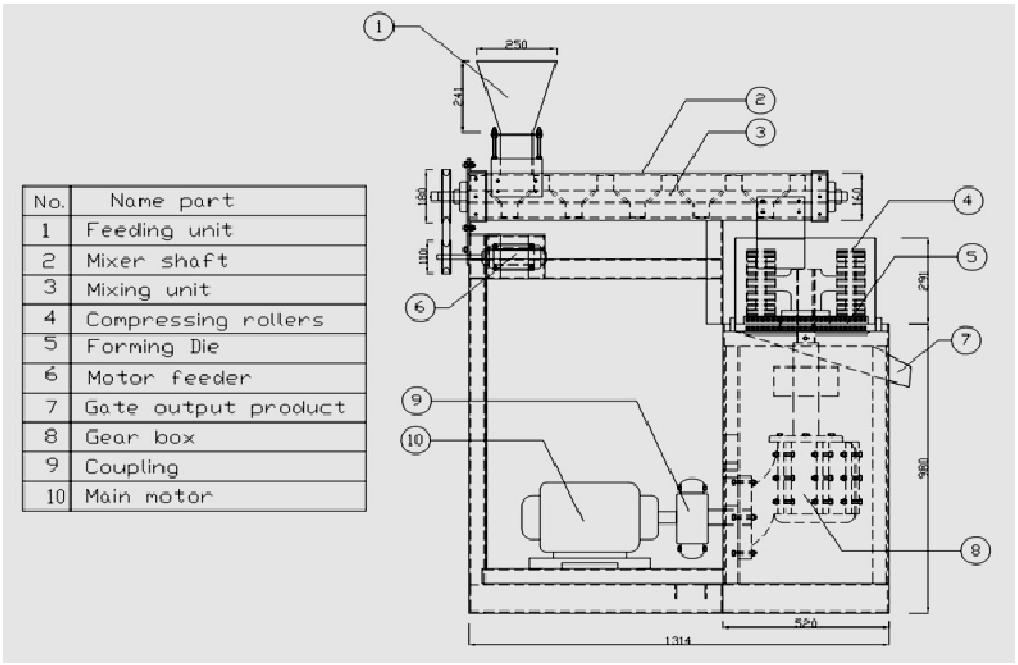
Residues formula

Ingredients	Percentage (%)
Barley grains	19.20
Wheat bran	28.50
Clover hay	30.90
Black seed meal	14.13
Corn grain	2.57
Molasses	3.00
Limestone	1.00
Sodium chloride	0.25
Premix	0.30
DL Methionine	0.15

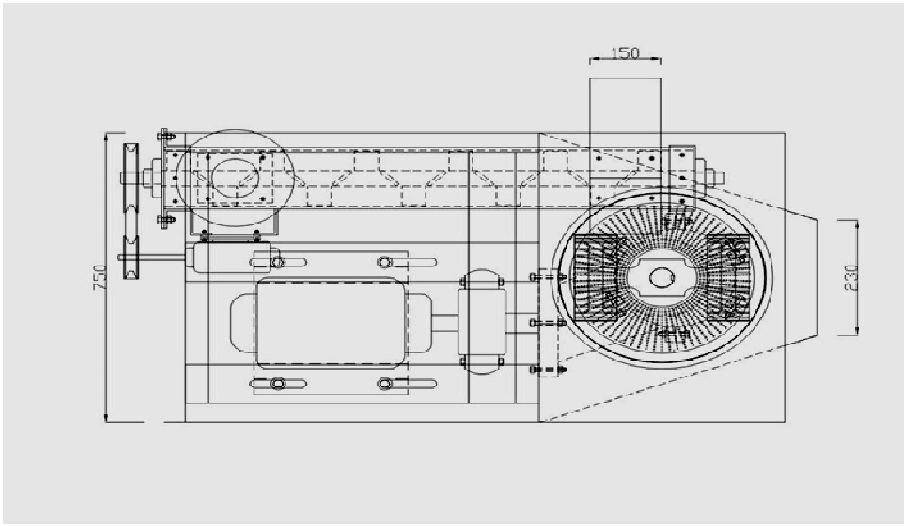
The raw material was prepared using a hammer mill with concave of 2mm holes diameter and feed to pellet mill through pre- conditioner to mix it with addition water as pending material, the addition water percentage were 7%, injection in pre-conditioner in begging and controlled by valve .

The specification of the compatible pellet machine:

The compatible pellet mill machine base was made from L shape steel sections, having dimension of 980 mm length, 520 mm width and 980 mm high as showing in Fig (1).



Dim. in mm Side view



Dim. in mm Plan view

Fig. 1. Layout of the machine showing different parts.

Feeding hopper:-

Feeding hopper made from sheet metal, has 2 mm thickness. It has conical shape; has diameters of 250 mm, and100 mm and 241 mm high. Transparent cylinder was constructed at the end of the feeding hopper is 80mm high as showing in Fig (2)

preconditioner :-

The raw materials were transported from feeding hopper to mixer. The pre conditioner as showing in Fig (3) was consisted of:

1- Abarrel:

It had diameter of 170 mm and length of 1120 mm

2- Mixer shaft

It was designed to transfer and turn the raw material from the beginning of the barrel to the end. The mixer shaft square shape dimensions were 40x40x1100 mm , and each of its end cylindrical shaft has cycle shape with diameter of 200 mm.

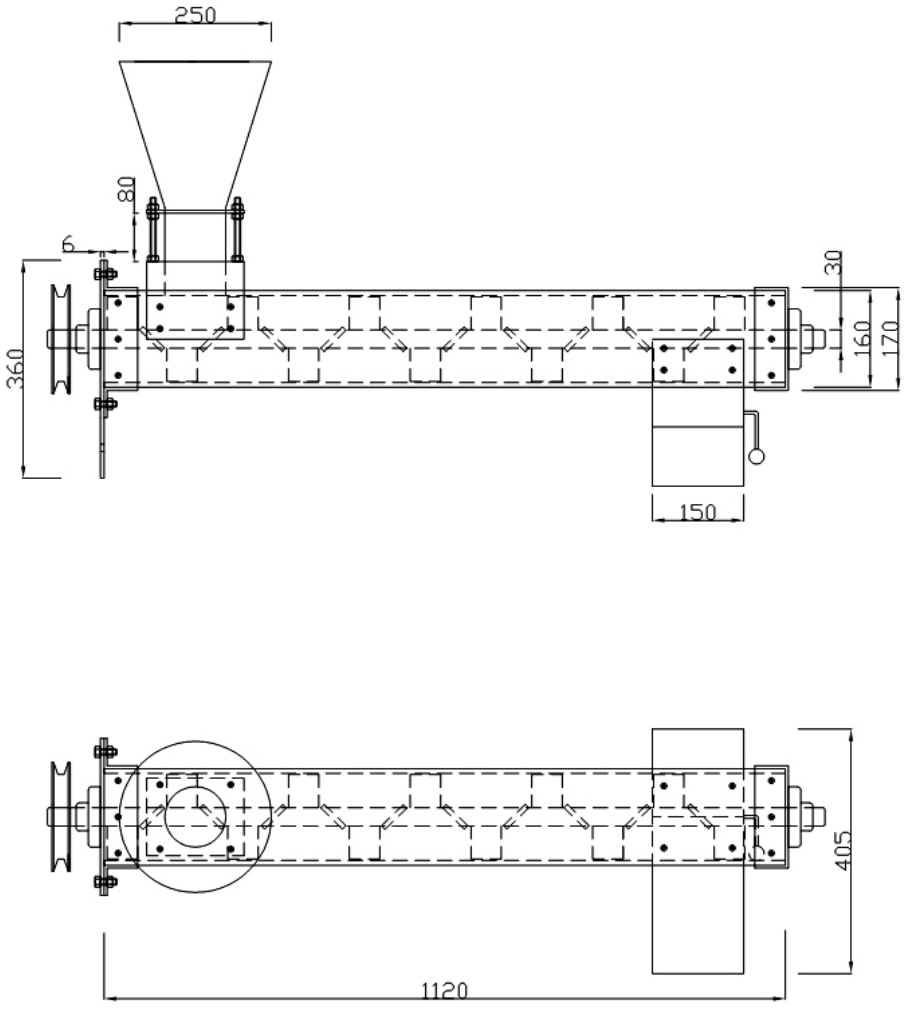
3- Pieces of iron sheet

It had square-shaped installed on a mixer shaft, it is working to move raw material from the beginning to the end of

4- The mixer cylinder.

Power transmission of pre conditioner :-

Power was transmitted from Pulley on the shaft of the motor, which has 110 mm diameter, to Pulley on the shaft of the mixer shaft which has 180 mm diameter by v. belt section .

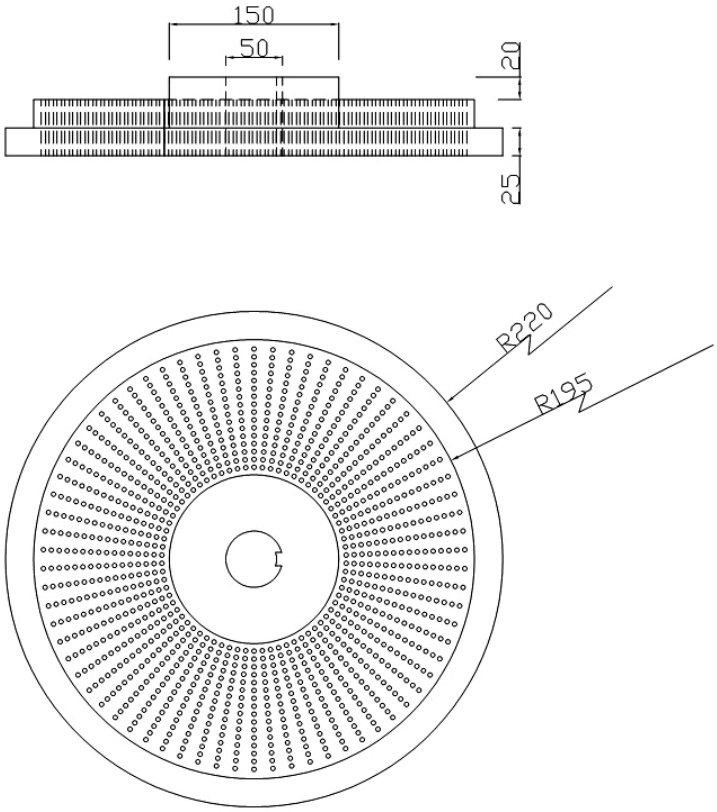


Dim. in mm Elevation and plan view.

Fig . 2. Pelleting machine feeding unit.

Forming unit (Die):-

The flat die consider the most important part in disk pellet mill machine. It is responsible to form the patch to pellets with the required diameter. The die material makes from very hard steel 52, it has dimension of 440 mm outer diameter and 50 mm inner diameter and thickness of 50 mm, 4 mm diameter circular openings, as shown in Fig (3).

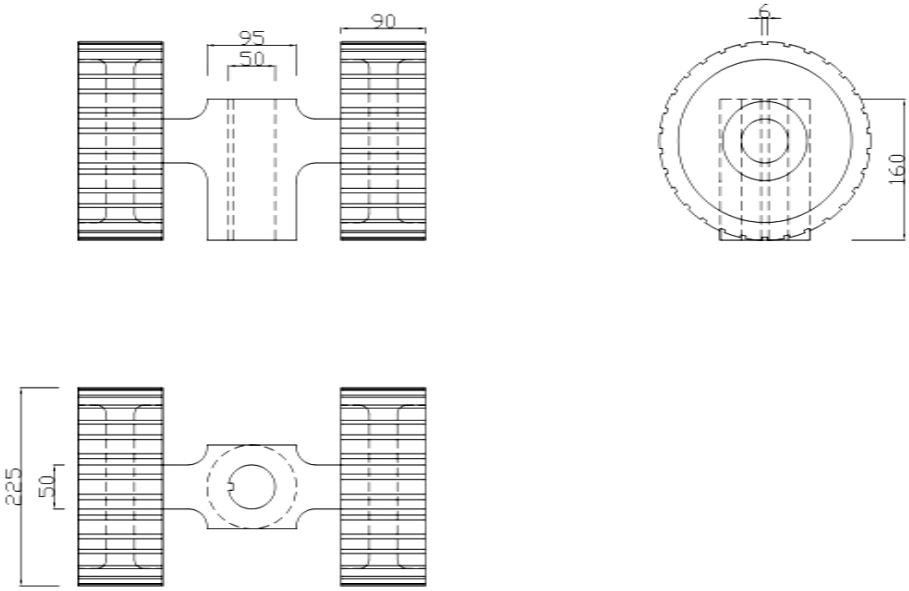


Dim. in mm Elevation and plan view

Fig. 3. Forming unit (Die).

The compressing unit (Rollers) :-

The compressing unit is responsible to compress and form the patch to pellets through the die holes. It consists of two rollers , both rollers are fabricated from high carbon steel and constructed by conical bearings on two horizontal bars which fixe on the center iron block. The compressing unit constructed on the top main moving shaft passing through the center of fixed die machine. Each of rollers is cylindrical in shape with the rollers cam base has dimension of 225 mm outer diameter, 50 mm innerr diameter and 90 mm width, the rollers unit constructed on the main shaft by keyway. , the rotating motion of the rollers is stable
motion around the horizontal bars which yields from the main shaft rotating motion. There is clearance between the die and the rollers is 0.5 mm extended according to the motion of the rollers around the horizontal bars for agreement with capacity of raw materials to force pressing through the die holes as shown in Fig (4).



Dim. in mm

Fig. .4. The compressing unit (Rollers) .

The main shaft :-

The main shaft made from hard steel with dimension as 300 mm length with extended diameter of 50 mm. The main shaft is fixed in a vertical position and assembled by two bearings. Two bearings with conical shape were assembled in the horizontal location , and the third one in flat shape are located in a vertical location to overcome the torsion stress during pelleting process . With both ends and full of oil bearings the main shaft at the bottom contacted by ring rigid joint with gear box which contactes by electric motor directly .

Cutter knife:-

The cutter knife made of stainless steel with dimension of 120 mm in length and 3 mm in thickness . It assembled on the main shaft directly under the die by cylindrical base which can changing the number of knife to change the product length and takes its motion from the main shaft . The clearance between the cutter knife and the lower surface of the die was 2 mm to give the suitable length of pellets out from the pressing unit.

Power transmission:-

The power is transfer from the main motor to rollers through gearbox. The main motor of flat die pellet mill machine has output power of 30 kW and 1400 rpm,

the main shaft connected with gear box shaft directly to transfer the power from the motor to rollers unit.

Measuring Instruments:

Digital tachometer:

Cole- Parmer 8204-00, digital tachometer (kit– Japan) is used for measuring the rotating speed of the main shaft.

Durability turning box:

A durability turning box consists of four cells rotated at constant speed of 60 rpm and is used to determine pellets durability.

Digital force gauge (shimpo):

digital force gauge was used to determine pellet hardness.

Methods:

Processing parameters:

Four different die L/D ratios of (5:1, 5.5:1, 6:1 and 6.5:1) , four mixing retention time of (2, 3.5, 4 and 5 min), using rollers teeth width of 10 mm were examined as a mechanical parameters and rabbit new formula including black seed meal were examined as physical parameters.

Evaluation of flat die pellet mill efficiency and product quality:

The pellet mill are evaluated as efficiency and pellets quality on the following measurements:

1- Compatible pellet unit production rate is measured for each treatment by taking sample for 2 kg after 10 min. of pellet mill running at steady condition

2- Specific mechanical energy (SME), is calculated as the following relation:

$$Total\ consumed\ \ power, (kW) = \frac{\sqrt{3}\ \ I\ \ V\ \ \eta\ \ \ \cos\theta}{1000}$$

Where: I = Line current strength in amperes;

V = Potential difference (Voltage) being equal to 380 V;

Cos θ = Power factor (being equal to 0.84); and

η = Mechanical efficiency assumed (90 %);

The SME is.MS, (kW.h/tons) is calculated by the following equation:

$$Energy\ consumed = \frac{P}{Q} = kW.h/ton$$

Where:

P = The consumed power for mixing ration, kW.

Q = Machinery line productivity, ton/h.

3- Pellet bulk density is calculated for irregular products by the standard methods of .

$$Bulk\ Density\ \ (g/cm^3) = \frac{Wd}{Vd}$$

Wd: pellets sample mass (g),and

Vd: pellets sample volume (cm^3)

4- Product durability is determined as ASAE standards method, at 3 replicates (mass of each one was 500 g) using turning box for 10 min.

$$Durability\,(\%) = \frac{Wa}{Wb} x100$$

Wa :pellets mass after treatment. (g),and

Wb: pellets mass before treatment. (g).

5- Mixing efficiency is calculated as the following:

$$\text{Mixing efficiency (\%)} = \frac{CPA}{CPB} x100$$

Where: CPA= crude protein after mixing and

CPB= crude protein before mixing

6- Pellets hardiness: Pellets hardness is measured by digital force gauge.

7- Cost per unit mass: It was calculated from the following formula:-

$$\text{Cost per unit mass} = \frac{machine\ \cos t(L.E/h)}{production\ (ton/h)}\ \text{(L.E/ton)}$$

RESULTS AND DISCUSSION

Evaluation of flat compatible pellet unit performance and product quality are carried out under the following items:.

1- Compatible Pellet unit Productivity:

Regarding for collected data as shown in Fig(5) it is found that increasing the pre-conditioner retention time from 2min to 3.5, 4 and 5 min decreased the pellet mill production from 454.67 to 448.25 , 442.48 and 436.7 kg/h using die L/D ratio of 5:1, from 434.29 to 427.87, 422.1 and 416.32 kg/h using die L/D ratio of 5.5:1, from 421.4 to 414.98, 409.21and 403.43kg /h using die L/D ratio of 6:1, from 402.56 to 396.14, 390.37 and 384.59 kg/h using die L/D ratio of 6.5:1.using rollers teeth width of 10 mm respectively.

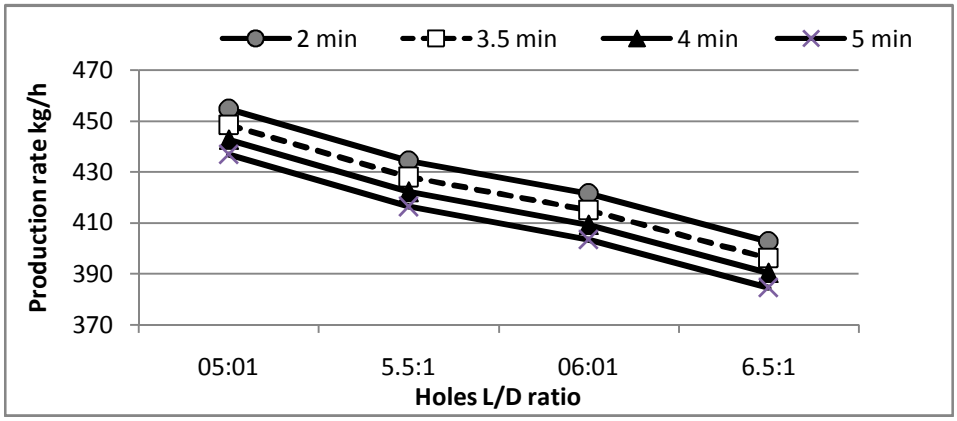


Fig. 5. Effect die L/D ratio on flat die pellet mill productivity using rollers teeth width of 10mm.

The decrease in flat die production rate by increasing the mixing retention time from 2 to 3.5 ,4 and 5 mincould be due to the decrease in pre conditioner shaft speed that lead to decrease the pellet mill feeding mass Also, the decrease in pellet mill production rate by increasing the die L/D ratio from 5:1 to 6.5:1 could be due to the increase in formula retention time inside the die holes that lead to decrease the product output in time unit.

2- Specific mechanical energy (SME): Energy requirements are a very important in economical analysis for any industry.

Is illustrated Regarding for collected data showed in Fig (6) it indicated that increasing the pre-conditioner retention time from 2min to 3.5, 4 and 5 min increasing the energy from 30.53 to 32.99, 34.44 and 35.97 Kw.h /ton using die L/D ratio of 5:1, from 35.30 to 37.96, 39.54 and 41.22 Kw.h /ton using die L/D ratio of 5.5:1, from 39.84 to 42.65, 44.35 and 46.15 Kw.h /ton using die L/D ratio of 6:1, from 45.58 to 48.62, 50.49 and 52.47 Kw.h /ton using die L/D ratio of 6.5:1 .using rollers teeth width of 10 mm respectively.

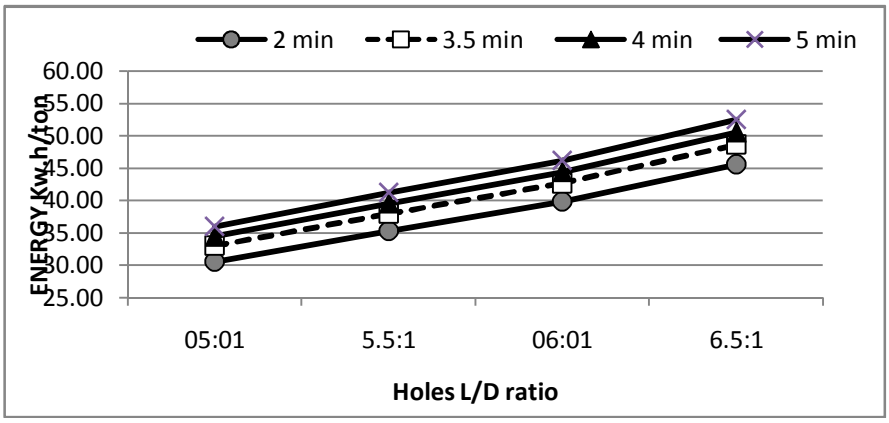


Fig. 6. Effect die L/D ratio , pre-conditioner retention time on energy requirements using rollers teeth width of 10mm.

3-mixing efficiency:

Regarding for collected data as shown in Fig (7) it is indicated that using die L/D ratio of 5:1, the pre conditionins retention time increasing from 2min to 3.5 and 4min the mixing efficiency increasing from 85.14 to 87.76 and 90.95 % but it decreased to 88.76 % at the pre conditionins retention time of 5 min, using die L/D ratio of 5.5:1, the pre conditionins retention time increasing from 2min to 3.5 and 4 min the mixing efficiency increasing from 85.65 to 88.29 and 91.48 % but it decreased to 89.29 % at the pre conditionins retention time of 5 min, using die L/D ratio of 6:1 the pre conditionins retention time increasing from 2min to 3.5 and 4min the mixing efficiency increasing from 85.77 to 88.4 and 91.59 % but it decreased to 89.39 % at the pre conditionins retention time of 5 min, using die L/D ratio of 6.5:1 the pre conditionins retention time increasing from 2min to 3.5 and 4min the mixing efficiency increasing from 85.82 to 88.43 and 91.62 % but it decreased to 89.45 % at the pre conditionins retention time of 5 min, rollers teeth of 10 mm.using residues formula respectively.

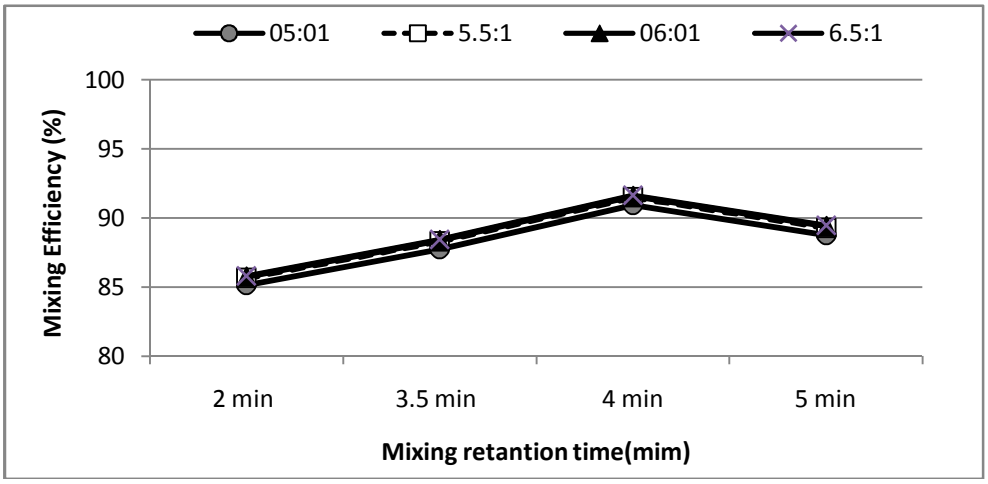


Fig. 7. Effect pre conditionins retention timeonmixing Efficiency using rollers teeth width of 10mm .

4 -Pellets bulk density:

Regarding for collected data showed in Fig (8) it is found that using die L/D ratio of 5:1 the pre conditionins retention time increasing from 2min to 3.5 min the bulck density increasing from 0.593 to 0.624 g/cm3 but it decreased to 0.579 , 0.56 g/cm3 at the pre conditionins retention time of 4, 5 min, using die L/D ratio of 5.5:1 the pre conditionins retention time increasing from 2min to 3.5 min the bulck density increasing from 0.64 to 0.671 g/cm3 but it decreased to 0.627, 0.607 g/cm3 at the pre conditionins retention time of 4,5 min, using die L/D ratio of 6:1 the pre conditionins retention time increasing from 2min to 3.5 min the bulck density increasing from 0.684 to 0.715 g/cm3 but it decreased to 0.671, 0.649 g/cm3 at the pre conditionins retention time of 4,5 min, using die L/D ratio of 6.5:1 the precondition retention time increasing from 2min to 3.5 min the bulck density increasing from 0.771 to 0.805 g/cm3 but it decreased to 0.761, 0.741 g/cm3 at the pre conditionins retention time of 4,5 min, under rollers teeth of 10 mm using residues formula respectively.

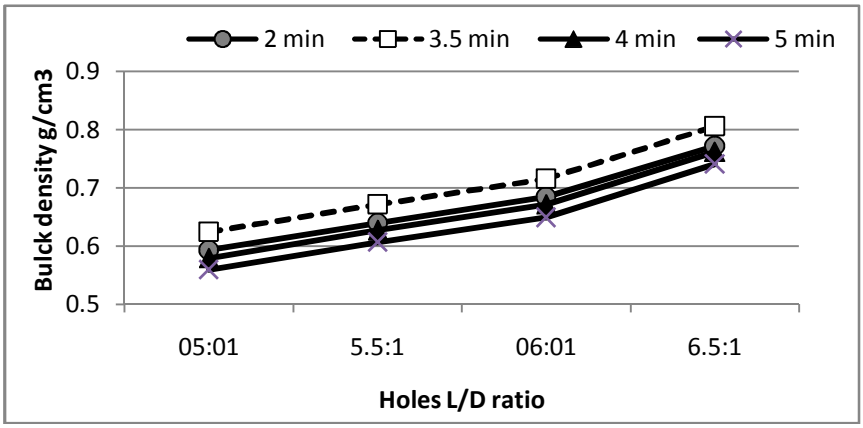


Fig. 8. Effect die L/D ratio , pre-conditioning retention time on bulk density using rollers teeth width of 10mm .

5-Pellets durability:

Regarding for collected data showed in Fig (9) it is indicated that using die L/D ratio of 5:1 the pre conditionins retention time increasing from 2min to 3.5 min the pellets durability increasing from 88.3 to 90.72 % but it decreased to 87.97, 85.41 % at the pre-conditioner retention time of 4, 5 min recpictavily, Using die L/D ratio of 5.5:1 the pre-conditioner retention time increase is from 2min to 3.5 min the pellets durability increasing from 90.79 to 93.21 % but it decreased to 90.46 , 87.9 % at the pre conditionins retention time of 4,5 min recpictavily. As using die L/D ratio of 6:1 the pre conditionins retention time increasing from 2min to 3.5 min the pellets durability increases from 91.97 to 94.39 % but it decreased to 91.64 , 89.08 % at the pre conditionins retention time of 4,5 min recpictavily. Finally using die L/D ratio of 6.5:1 the pre conditionins retention time increasing from 2min to 3.5 min the pellets durability increasing from 94.53 to 96.95 % but it decreased to 94.2 , 91.64 % at the pre conditionins retention time of 4,5 min recpictavily, under rollers teeth of 10 mm using residues formula .

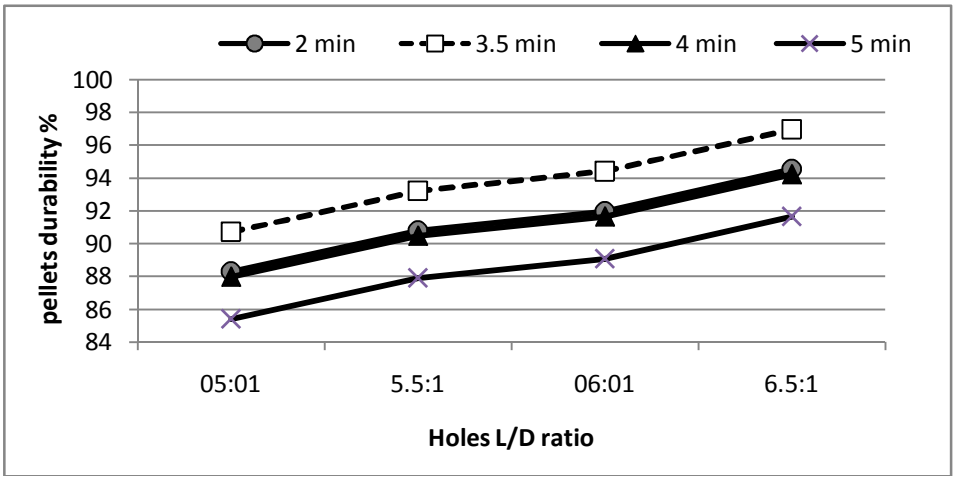


Fig. 9. Effect die L/D ratio , pre-conditioner retention time on pellets durability using rollers teeth width of 10mm .

6–Pellets hardiness:

Regarding for collected data showed in Fig (10) is indicated that using die L/D ratio of 5:1, the pre conditionins retention time increases from 2min to 3.5 min the pellets hardness increases from 45.3 to 46.84 N but it decreased to 44.06 , 43.86 N at the pre conditionins retention time of 4, 5 min recpictavily. Using die L/D ratio of 5.5:1 the pre conditionins retention time increasing from 2min to 3.5 min the pellets hardness increases from 47.47 to 49.01 N but it decreass to 46.23, 46.03 N at the pre conditionins. As using die L/D ratio of 6:1 the pre conditioner retention time increasing from 2min to 3.5 min the pellets hardness increases from 49.5 to 51.04 N but it decreased to 48.26, 48.06 N at the pre conditionins retention time of 4,5 min recpictavily.using die L/D ratio of 6.5:1 the pre conditionins retention time increasing from 2min to 3.5 min the pellets hardness increases from 56.16 to 57.7 N but it decreased to 54.92 , 54.72 N at the pre conditionins retention time of 4,5 min recpictavily, under rollers teeth of 10 mm using residues formula .

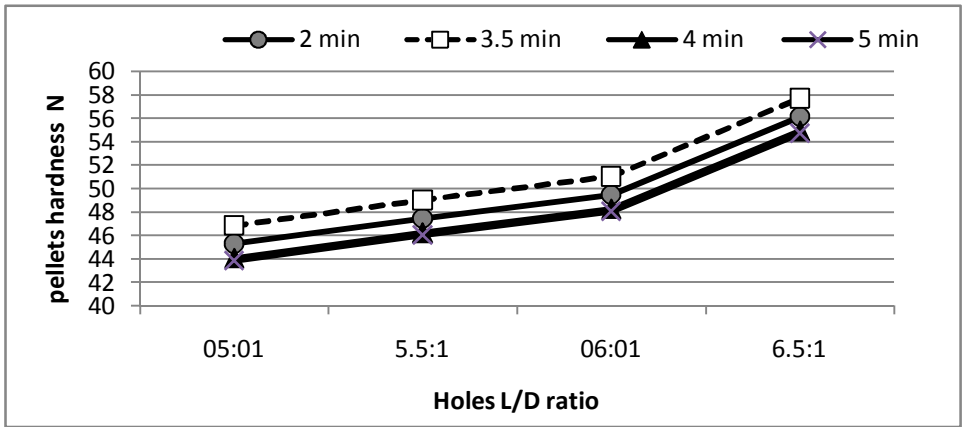


Fig. 10. Effect die L/D ratio , pre-conditioner retention time onpellets hardnessusing rollers teeth width of 10mm .

7 -Cost of pellets unit mass: It is very important to know what is the advantage of manufacture a simple unit of flat die pelleting machine and use some of residues formulation including black seed meal in rabbits formula economically. as:

Regarding for collected data showed in Fig 11 it is found that increasing the pre conditionins retention time from 2min to 3.5, 4 and 5 min increases the cost from 521.85 to 532.96, 541.22 and 553.90 LE/h. Using die L/D ratio of 5:1, from 554.24 to 566.36, 575.48 and 589.26 LE/h. As using die L/D ratio of 5.5:1,cost increases from 578.12 to 590.99, 600.74 and 615.32 LE/h. And using die L/D ratio of 6:1,cost increases from 623.83 to 638.06, 648.97, and 664.99 LE/h. And finally using die L/D ratio of 6.5:1 .

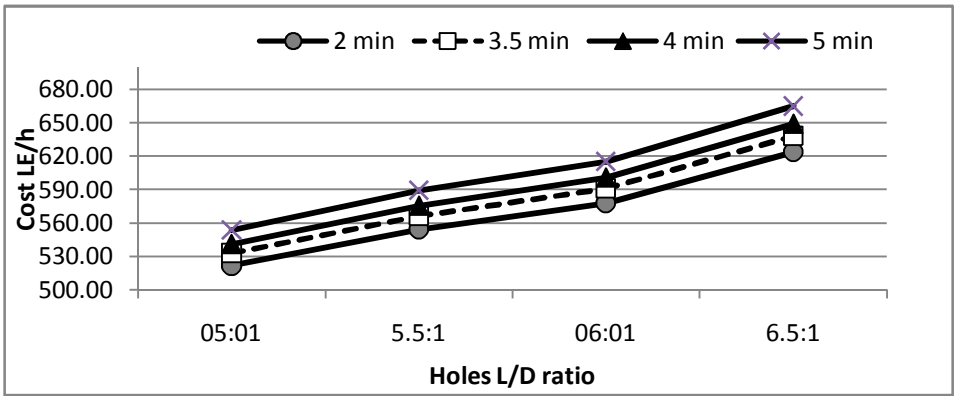


Fig. 11. Effect die L/D ratio, pre-conditioner retention time on cost using rollers teeth width of 10mm.

CONCLUSIONS

The important results obtained data may be summarized in the following recommended points:

1- The preferred die L/D ratio is 5.5:1 for achieving high machine efficiency and pellets quality.

2- The preferred pre-conditioner retention timeis 3.5 min for high machine efficiency and pellets quality .

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تصنيع وتقييم وحدة مجمعة لإنتاج الأعلاف الحيوانية المصبعة

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تهدف الدراسة إلي تصنيع وتقييم آلة تكعيب أعلاف ذات مشكل أعلاف أفقي لإنتاج أعلاف خاصة الأرانب عالية الجودة. باستخدام مخلفات كسب حبة البركة في التركيبات العلفية. حيث تم تصنيع الآلة بورشة بمدينة الزقازيق محافظة الشرقية وتم تجربة الآلة وعمل التجارب بمعهد بحوث الهندسة الزراعية بالدقي وتم دراسة بعض العوامل الفيزيقية والميكانيكية التي تؤثر على أداء الآلة وجودة العلف المنتج. وفي هذه الدراسة كان وقت زمن الخلط ٢و٣,٥ و٤ و٥ دقيقة ، وأيضا اربع نسب لطول السمك المؤثر لثقب الداى (L/D) (١:٥ و١:٥,٥ و١:٦و١:٦,٥) ، وكذلك عرض سنة بكر الضغط ١٠مم.

أوضحت النتائج أن زيادة زمن الخلط من ٢ إلي ٥ دقيقة أدت إلى زيادة الإنتاجية وانخفاض الطاقة المستهلكة لإنتاج وحدة الكتلة من العلف.بينما زيادة نسبة الطول الفعال لسمك الداى (L/D) من ١:٥ إلي١:٦,٥ أدت إلى انخفاض في الإنتاجية وزيادة مضطردة للطاقة المستهلكة. وعلى الجانب الأخر فان زيادة (L/D) من ١:٥ إلي١:٦,٥ وكذلك زيادة زمن الخلط من ٢ إلي٣.٥ دقيقة أدت إلى زيادة كثافة العلف ومتانته ومقاومته للنقل والصدمات.

كما أن أفضل المعاملات التي يمكن الحصول منها على أعلى كفاءة للآلة وأفضل جودة للعلف المنتج. نسبة (L/D)١:٥,٥ ، وأفضل زمن خلط لتركيبة العلفية ٣,٥ دقيقة ، عرض سنة للبكر ١٠ مم ، باستخدام تركيبة المخلفات ، وأعطت المعاملات السابقة ٨٧ و٤٢٧ كجم /ساعة لإنتاجية الآلة ، ٩٦و٣٧ كيلو وات ساعة / طن للطاقة المستهلكة لإنتاج وحدة الكتلة من العلف المنتج، ٢٩ و٨٨ % كفاءة الخلط ، ٦٧١و جم /سم٣ لكثافة العلف المنتج ، ٢١و٩٣% مقاومة العلف للنقل والصدمات ، ٠١و٤٩ نيوتن صلابة العلف ، ٣٦ و٥٦٦ جنية مصري / طن.