Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 15, Issue 2, 2015
PRINT ISSN 2284-7995, E-ISSN 2285-3952

MANUFACTURING AND PERFORMANCE EVALUATION OF A COMPATIBLE UNIT TO PRODUCE ANIMAL FEED PELLETS

Tarek FOUDA, Adel ELMETWALLI, O. KADDOUR, **Asaad DERBALA**, **K. ABDEL-MOHSEN**

Tanta university, Faculty of agriculture, Egypt, Phone: +20403455584, Fax: +20403455570, Mobile: +20128476266, Emails: tfouda @yahoo.com, adelra99@yahoo.com, derbalana@yahoo.com

Corresponding author: tfouda @yahoo.com

Abstract

The main objective of this research was to manufacture and evaluate a compatible unit including mixing and pelleting to produce Rabbit feed pellets formula in one operation. The compatible was evaluated under operating parameters including four different retention time (2, 3.5,4 and 5min) and four L/D ratio (5:1 5.5:1, 6:1and 6.5:1) were investigated under the above mentioned parameters. The optimum results compatible unit were die L/D ratio of 5.5:1, 3.5min of mixing retention time, and rollers teeth width of 10mm. 427.87kg/h production rate 37.96 kW.h/ton energy requirement.88.29% mixing efficiency, 0.671gm /cm^3 bulk density, 93.21% durability, 49.01N hardiness, and 566.36 LE/ton using residues formulation including black seed meal.

***Key words**: evaluate, compatible unit, manufacture, pelleting*

INTRODUCTION

Rabbit production has potential in developing countries as a mean of supplying cheap high quality animal protein within the shortest possible time. Animal feed produce errs take always care about pellet quality which is affected by many factors. Pellets quality fundamentally affects the profitableness of the product and this mainly depends on mixing and pelting process one considered on important to improve the pellet specification such as bulk density, durability, hardiness and lowering costs and getting high quality in the same time.

Agricultural residues represent an extreme problem in Egypt facing the people and state with economic, environmental and healthy aspects. The annual amount of crop residues is almost 25-35 million tons.

Pelleting is considered to have an important role in animal performance. It is very useful in materials handling since it improves the specifications of the material. It increases bulk density and prevents the segregation of different ingredients. It is therefore very important to testify different parameters affecting pellet mill machines and choose the optimum operating conditions.

the Indian Grassland and fodder Research Institute (IGFI) developed an animal feed pelleting machine for making feed pellets from poultry droppings. The size of the pellets varies from 8mm to 38mm in diameter and from 20 to 60 mm in length depending upon the need of different animals[3].

Hardness results at different temperatures. Temperature is believed to affect quality but hardness results appear to be random. In another trial hardness had a negative correlation to durability.

This is rare but it can occur. It appeared that molasses was added at variable levels during the pelleting run.

Addition of molasses can make the pellet soft and gummy; it may even be possible to bend the pellet. Soft pellets can be very durable, making the hardness test an inappropriate method of measuring quality [5].

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 wear more evenly[1].

Limited the operating conditions which affect the quality of pellets feed as follows: pellet die thickness as related to diameter of hole, speed of ration should be also considered for each die

thickens/hole diameter combination[1].
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 on 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 by pellets[4].
Quality of the final pellets depends on the process before the die (milling and mixing), Pelleting conditions and the process after the die (drying and cooling).For the pellet milling process, there is a general agreement on the contribution of different factors on the durability of feed pellets. The relative role of diet formulation is reported to be 40%, while that of particle size, steam conditioning, die specifications and cooling/drying are 20, 20, 15 and 5%, respectively. When including an expander in the conditioning process, the distribution becomes 25, 15, 40, 15 and 5%, respectively, for diet formulation, particle size, steam and expander conditioning, die specifications, and cooling/drying [6].
The objectives:
of this manufacture of a compatible unit to produce Rabbit feed pellets from black seed meal residues.
Optimizing operating parameters (Retention time, L/D ratio, Rollers speed , and Rollers teeth affecting the performance of manufacture compatible unit.

MATERIALS AND METHODS

Compatible unit to produce Rabbit feed pellets was manufactured in Zagazig city and evaluated at the institute of Agricultural engineering. Giza, Cairo.
A rabbit experimental ration was used in the present study; it has composition as shown in table 1.
The raw material was prepared to dropped under the hopper. The material is mixed by Water in conditioner (auger) - the mixture is pressed by the rollers inside the die holes – the pellets exits from the die.

Table 1. Composition of the experimental ration

Stander formula		Residues formula	
ingredients)	Percentage	ingredients	Percentage
Barley grains	19.20	Barley grains	19.20
Wheat bran	28.50	Wheat bran	28.50
Clover hay	30.90	Clover hay	30.90
Soybean meal	5.00	Black seed meal	14.13
Corn grain	11.7	Corn grain	2.57
Molasses	3.00	Molasses	3.00
Limestone	1.00	Limestone	1.00
Sodium chloride	0.25	Sodium chloride	0.25
Premix	0.30	Premix	0.30
DL Methionine	0.15	DL Methionine	0.15
TOTAL	100%	TOTAL	100%

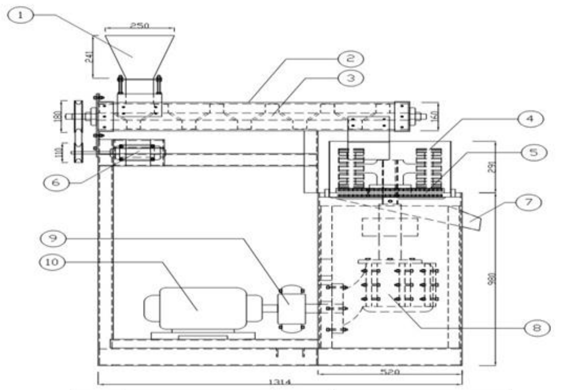
Technical specifications of the Compatible unit Machine:
The Compatible unit base was made from L shape steel sections, having dimension of 1314 mm length, 750 mm width and 980 mm height as shown in Fig (1).

Forming unit (Die)

The flat die is considered the most important part in disk pellet mill machines. It is responsible to form the Mach to pellets with the required diameter. The die material was made from a very hard steel C52 having dimensions of 440 mm outer diameter, 50 mm inner diameter and 32 mm thickness as illustrated in Fig (2).

The compressing unit (Rollers)

The compressing unit was responsible to compress and form the mach to pellets through the die holes.
It consists of two rollers, fabricated from hard steel and constructed by conical bearings on two horizontal bars which fixed on a central iron block.
The compressing unit was constructed on the top of main moving shaft passing through the center of fixed die machine. Each roller is cylindrical in shape. The rollers cam base has dimensions of 225 mm outer diameter, 50 mm inner diameter and 90 mm width. The rotating motion of the rollers was stable around the horizontal bars which were yielded from the main shaft rotating motion.
A 0.5 mm clearance between the die and the rollers extended according to the motion of the rollers around the horizontal bars for agreement with capacity of row materials to force pressing through the die holes as shown in Fig. (3).



NO	Part Of Name	NO	Part Of Name
1	Feeding unit	6	Motor conditioner shaft
2	Pre-conditioner	7	Gat output product
3	conditioner shaft	8	Gear box
4	Compressing rollers	9	Coupling
5	Forming die	10	Main motor

Fig. 1. Elevation of view the Compatible unit showing different parts.

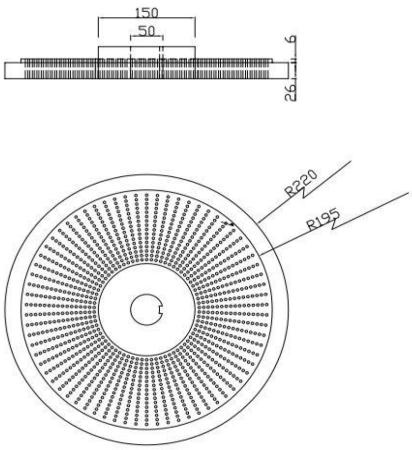


Fig. 2. Forming unit (Die)

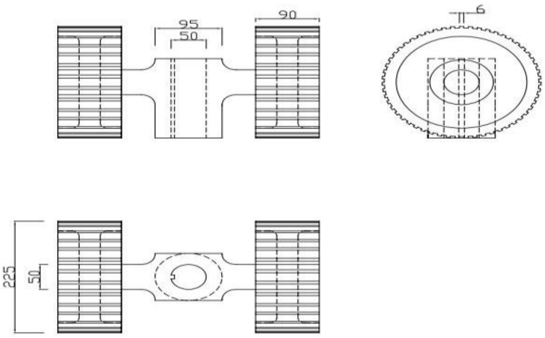


Fig. 3. Elevation, plan, and side view of compressing unit (Rollers).

Methods:

Processing Parameters.

These two parameters were investigated using rollers teeth width of 10 mm to choose the optimum operating conditions to produce new rabbet formula. Using a digital tachometer (Cole- Parmer 8204-00, kit– Japan) was used for measuring the rotating speed of the main shaft.

Evaluation of a Compatible unit efficiency and product quality.

Rabbit formula was produced by a local Compatible unit using dies with
4mm diameter circular openings. The Compatible unit performance was evaluated for Compatible unit efficiency and pellets quality based on the following measurements:

1.Pellet a Compatible unit productivity which was measured for each treatment by taking a sample for 2 min. At the beginning, the machine was operated for 10 mm to reach the steady condition before collecting samples.

2.Specific mechanical energy (SME), was calculated using the following equation:

Energy requirement

Energy requirement in kW.h/ton was calculated using the following equation:

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

Where:

I = Line current strength in amperes.
P = consumed power for mixing ration, kW.
Q = Machinery line productivity, ton/h.

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

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).
η = Mechanical efficiency (assumed 90 %).

RESULTS AND DISCUSSIONS

1.Compatible unit Productivity

Besides formulation, formula moisture content and particle size, die and rolls specifications are the most important measurements affecting flat die mill machine productivity.

Fig. 4 depicts the effects of die L/D ratio on the pellet mill machine productivity at different retention times.

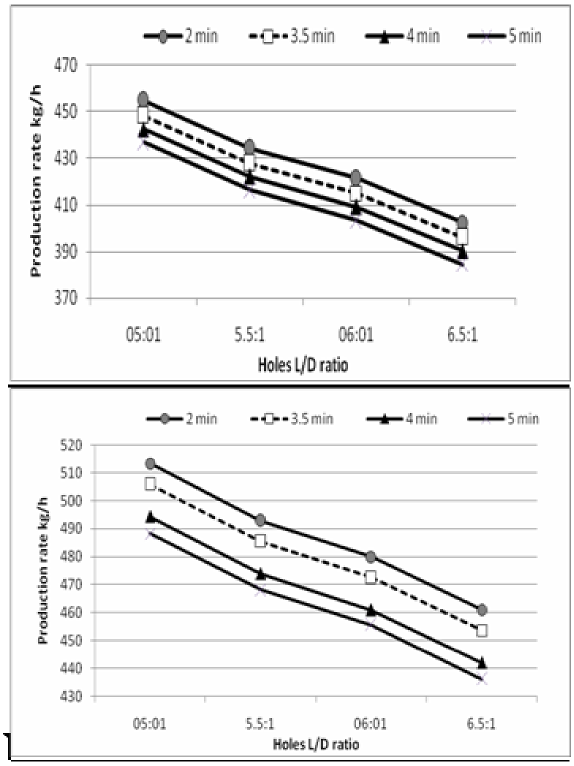


Fig. 4. Effect of die L/D ratio on productivity using rollers teeth width of 10 mm at different pre-conditioner retention time.

It is obvious that increasing the die L/D ratio from 5:1 to 6.5:1 decreased the mill machine productivity at all used retention times. increasing die L/D ratio from 5:1 to 5.5:1, 6:1 and 6.5:1 decreased the pellet mill production from 454.67 to 434.29, 421.4 and 402.56 kg/h at 2 min pre-conditioner time; from 448.25 to 427.87, 414.98 and 396.14 kg/h at 3.5 min; from 442.48 to 422.1, 409.21, and 390.37 kg/h at 4 min, and from 436.7 to 416.32, 403.43 and 384.59 kg/h at 5 min. these results were recorded with the residues formula.

The results obtained with the standard formula had the same trend since increasing die L/D ratio from 5:1 to 5.5:1, 6:1 and 6.5:1 decreased the pellet mill production by 19, 10, 11 and 11% at 2, 3.5, 4 and 5 min retention times respectively.

The decrease in flat die production rate by increasing the mixing retention time from 2 to 3.5, 4 and 5 min could 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 very important in economical analysis for any industrial operation.

Fig. 5 illustrates the effect of die L/D ratio on energy requirements at different retention time.

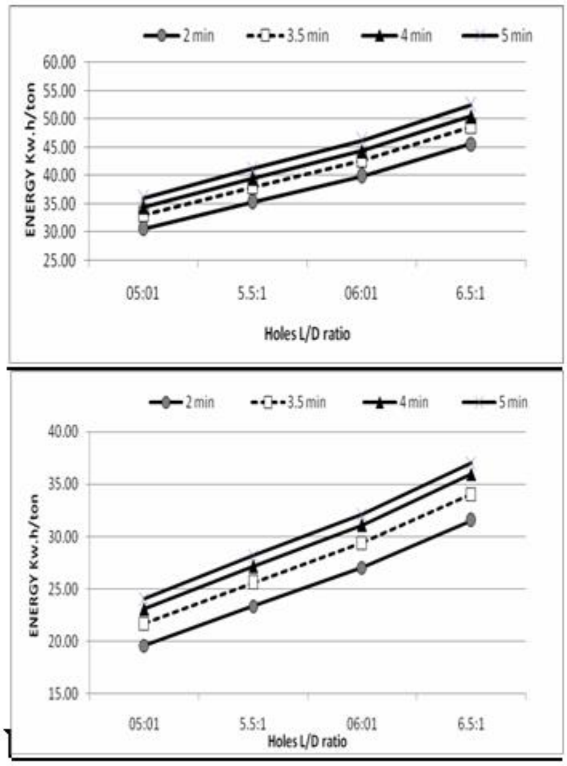


Fig. 5. Effect of die L/D ratio on energy requirements using rollers teeth width of 10 mm at different pre-conditioner retention time.

It is indicated that increasing die L/D ratio from 5:1 to 6.5:1 increased the consumed power at all retention times. The results demonstrated that increasing die L/D ratio from 5:1 to 5.5:1, 6:1 and 6.5:1 increased specific mechanical energy from 30.53 to 35.30, 39.84 and 45.58 kW.h/ton at 2 min pre-conditioner time; from 32.99 to 37.96, 42.65 and 48.62 kW.h /ton at 3.5 min; from 34.44 to 39.54, 44.35, and 50.49 kW.h /ton at 4 min and from 35.97 to 41.22, 46.15 and 52.47 kW.h /ton at 5 min retention time. Same results were obtained with standard formula as with increasing L/D ratio from 5:1 to 6.5:1 increased the consumed power by 61, 57, 55 and 53% at 2, 3.5, 4 and 5 min retention times respectively. Increasing specific energy by increasing die L/D ratio may have been a result of increasing power consumed and decreasing the pellet mill productivity.

3.Mixing efficiency

Fig. 6 depicts the relationship between L/D ratio and mixing efficiency showing that increasing die L/D ratio from 5:1to 5.5:1, 6:1 and 6.5:1 increased the mixing efficiency from 85.14 to 85.65, 85.77 and 85.82 % at 2 min pre-conditioner time; from 87.76 to 88.29, 88.4 and 88.43 % , at 3.5 min pre-conditioner time; from 90.95 to 91.48 , 91.59 , and 91.62 % at 4 min and from 88.76 to 89.29 , 89.39 and 89.45 % and at 5 min pre-conditioner time.

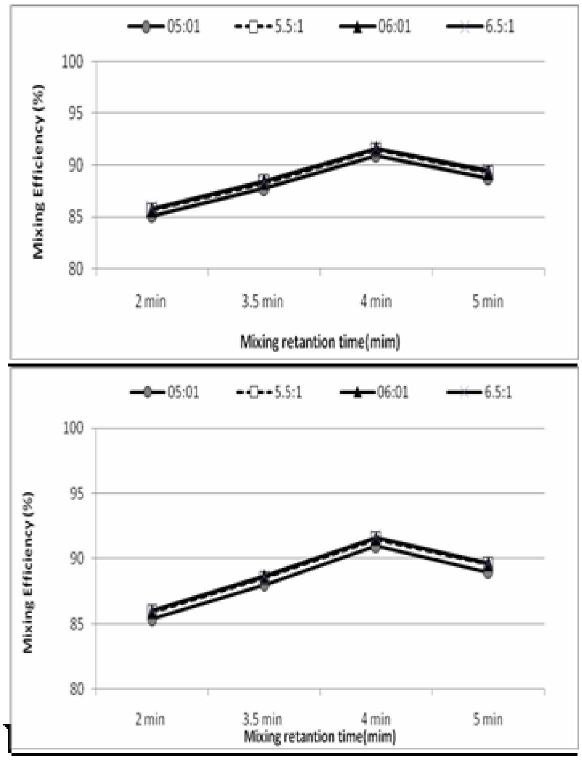


Fig. 6. Effect pre-conditioner retention time on mixing Efficiency using rollers teeth width of 10 mm.

Same results were obtained with standard formula as with increasing L/D ratio from 5:1 to 6.5:1 increased the mixing efficiency by (0.8, 0.7, 0.8 and 0.7%)% at 2, 3.5, 4 and 5 min retention times respectively. increasing The mixing efficiency by increasing the mixing retention time from 2 to 4 minutes could be due to The Homogeneity of ingredients mixture components. Also, decreasing The mixing efficiency by increasing the mixing retention time from 4 to 5 minutes could be due to the scattering ingredients formula and decreasing The Homogeneity of mixture components.

4.Pellets bulk density

Pellets bulk density is one of the most important targets of any feed manufacturing industry. The results presented in Fig.7 showed that increasing die L/D ratio of 5:1 the pre-conditioner retention time increasing from 2min to 3.5 min the bulk density increasing from 0.593 to 0.624 g/cm3 but it decreased to 0.579 , 0.56 g/cm3 at the pre-conditioner retention time of 4, 5 min, using die L/D ratio of 5.5:1 the pre-conditioner 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-conditioner retention time of 4 and 5 min, using die L/D ratio of 6:1 the pre-conditioner 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-conditioner retention time of 4,5 min, using die L/D ratio of 6.5:1 the pre-conditioner 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-conditioner retention time of 4 and 5 min, Same results were obtained with standard formula as with increasing L/D ratio from 5:1 to 6.5:1 increased the bulk density by 30, 28, 26 and 28 % at 2, 3.5, 4 and 5 min retention times respectively. Increasing the bulk density by increasing the die L/D ratio from 5 :1 to 6.5 :1 could be due to the increasing of pressing time inside the die holes and increasing the compressing of mixture particles accordingly. the pellets mass increased by increasing the pressing time. . Also, increasing the bulk density by increasing the retention time from 2 to 3.5 minutes could be due to the homogenous of mixture particles meanwhile the decreasing the pellets bulk density by increasing retention time from 3.5 to 5minutes could be due to scattering formula.

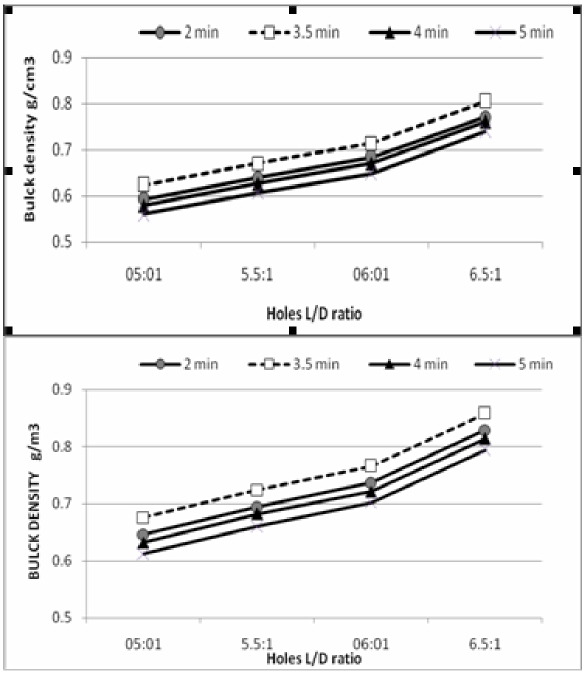


Fig. 7. Effect die L/D ratio, on bulk density using rollers teeth width of 10 mm at different pre-conditioner retention time.

5.Pellets durability

Die L/D ratio mainly the most parameter affecting pellets durability. Regarding the collected data showed in Fig. 8, it indicated that using die L/D ratio of 5:1 the pre-conditioner retention time increasing from 2 min 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 increasing 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-conditioner retention time of 4,5 min recpictavily, using die L/D ratio of 6:1 the pre-conditioner retention time increasing from 2min to 3.5 min the pellets durability increasing from 91.97 to 94.39 % but it decreased to 91.64 , 89.08 % at the pre-conditioner retention time of 4,5 min recpictavily, using die L/D ratio of 6.5:1 the pre-conditioner 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-

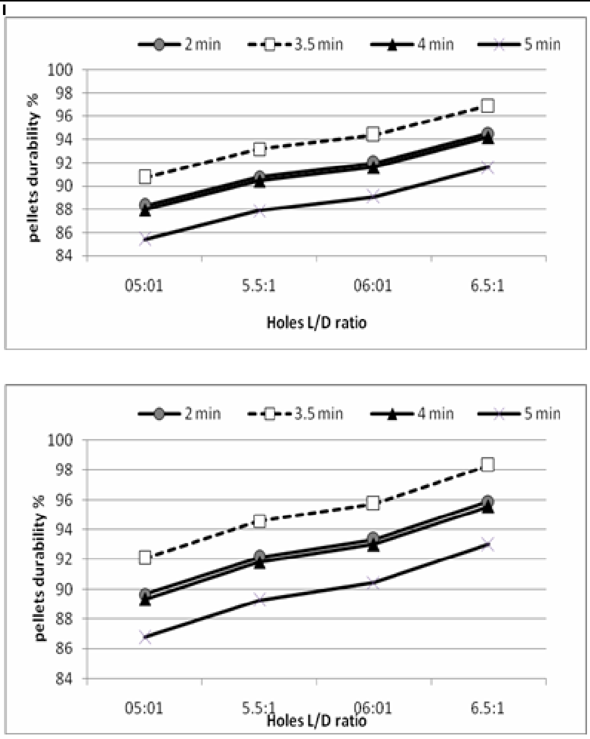


Fig. 8. Effect die L/D ratio, on pellets durability using rollers teeth width of 10 mm at different pre-conditioner retention time.

conditioner retention time of 4,5 min recpictavily, under using rollers teeth of 10 mm, residues formula.

The same results were obtained with standard formula as with increasing L/D ratio from 5:1 to 6.5:1 increased the pellets durability by 7, 7, 8 and 7 % at 2, 3.5, 4 and 5 min retention times respectively, increasing the pellets durability by increasing the die L/D ratio from 5 :1 to 6.5:1, increasing the pressing time inside the die holes could be due to the increasing of pellets mass and decreasing the pores inside the pellets.

Also, increasing the pellets durability by increasing the retention time from 2 to 3.5 minutes could be due to increasing the pellets bulk density and decreasing the pores inside the pellets. meanwhile the decreasing the pellets durability by increasing the retention time from 3.5 to5 minutes could be due to the decreasing of pellets durability and increasing the pores inside the pellets.

6.Pellets hardiness

The data showed in Fig.9 indicated that using die L/D ratio of 5:1 the pre-conditioner retention time increasing from 2min to 3.5 min the pellets hardness increasing from 45.3 to

46.84 N but it decreased to 44.06 , 43.86 N at the pre-conditioner retention time of 4, 5 min recpictavily.

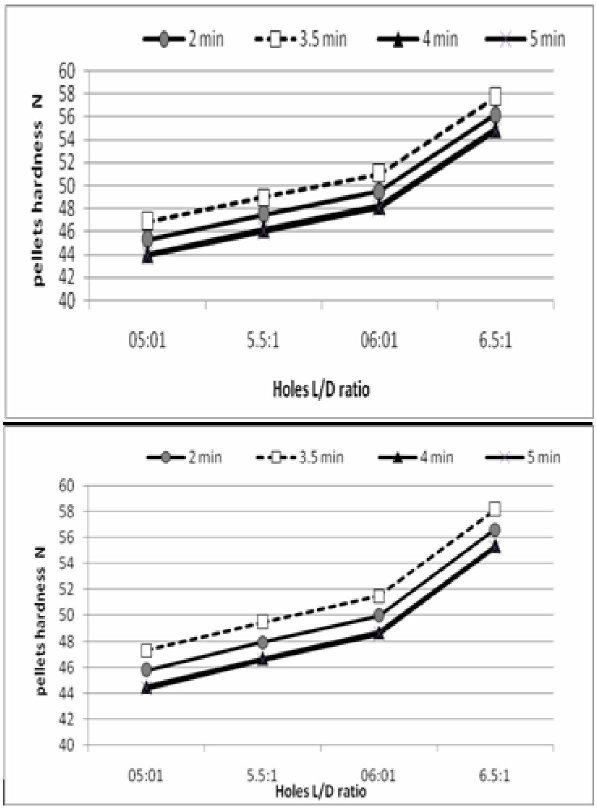


Fig. 9. Effect die L/D ratio, on pellets hardness using rollers teeth width of 10 mm at different pre-conditioner retention time.

Using die L/D ratio of 5.5:1 the pre-conditioner retention time increased from 2min to 3.5 min the pellets hardness increasing from 47.47 to 49.01 N, but it decreased to 46.23, 46.03 N at the pre-conditioner retention time of 4,5 min recpictavily, using die L/D ratio of 6:1 the pre-conditioner retention time increasing from 2min to 3.5 min the pellets hardness increasing from 49.5 to 51.04 N but it decreased to 48.26, 48.06 N at the pre-conditioner retention time of 4,5 min recpictavily, using die L/D ratio of 6.5:1 the pre-conditioner retention time increasing from 2 min to 3.5 min the pellets hardness increasing from 56.16 to 57.7 N but it decreased to 54.92, 54.72 N at the pre-conditioner retention time of 4,5 min recpictavily, under rollers teeth width of 10 mm using residues formula.

The same results were obtained with standard formula as with increasing L/D ratio from 5:1 to 6.5:1 increased the pellets hardness by 24, 24, 22 and 24 % at 2, 3.5, 4 and 5 min retention times respectively.

Increasing the pellets hardness by increasing the die L/D ratio from 5:1 to 6.5:1, could be due to the increasing the pellets bulk density according to the increasing the pressing time inside the die holes. Also, increasing the pellets hardness by increasing of the homogenous of mixture particles meanwhile the decreasing the pellets hardness by increasing the retention time from 3.to 5 minutes could be due to a low homogenous of mixture particles.

7.Cost of rabbit 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.

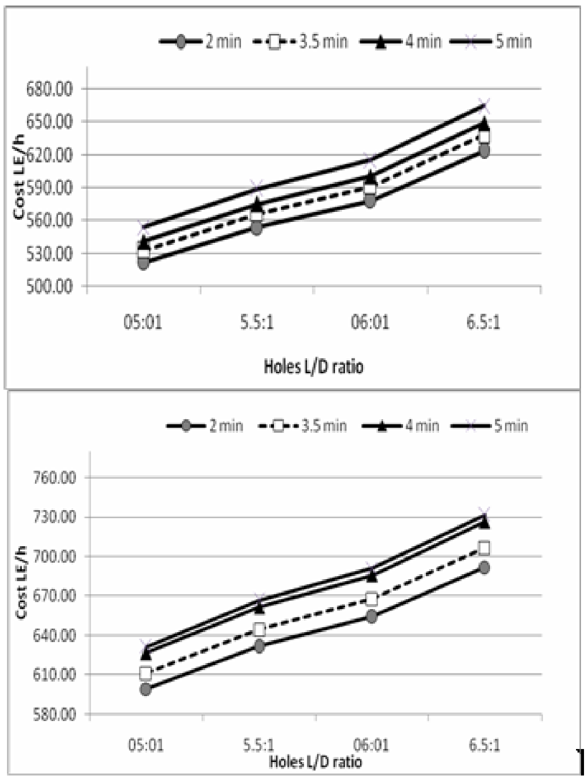


Fig. 10. Effect die L/D ratio, on cost using rollers teeth width of 10 mm at different pre-conditioner retention time.

Regarding for collected data showed in Fig. 10, it indicated that increasing the pre-conditioner retention time from 2min to 3.5, 4 and 5 min increasing 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 using die L/D ratio of 5.5:1, from 578.12 to 590.99, 600.74 and 615.32 LE/h using die L/D ratio of 6:1, from 623.83 to 638.06, 648.97, and 664.99 LE/h using die L/D ratio of 6.5:1.

The same results were obtained with standard formula as with increasing L/D ratio from 5:1 to 6.5:1 increased the cost by 15, 15, 16 and 15 % at 2, 3.5, 4 and 5 min retention times respectively.

The minimum operation cost of (521.85 L.E. /ton), (599.26 L.E. /ton) was obtained by using the constructed machine at mixing retention time of 2 minute, die L/D ration of 5:1 and of pressing rollers teeth width of 10 mm for residues and stander formula recpictavily.

CONCLUSIONS

The important results obtained may be summarized in the following recommendations:

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

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

The preferred rollers teeth width is 10 mm for the flat die pellet mill.

REFERENCES

[1]David, A.F., 2003, "Pelleting for profit-part2. National Grain and feed association. Feed and feeding digest", Vol, 54, No. 7, December 22.

[2]Hasting, W.H., 2003, Feed milling process. Mt. Vernon, Washington D. Higgs Enviroment Canda, Van cover, British Columbia.

[3]Gupata, P.D., Goyal, R.K., 1999, Pillarization of different animal feeds using IGFRI pelleting machine - an analysis of feeding trial Processing Equipment and Technology, Vol. 20, Issue 1, pp 70-77.

[4]Kaddour, U.A., Ewes, T.A., Afify M.K., 2006, Influences of Geometrical dimension of extrusion die holes on machine efficiency and pellets quality. 4th annual conference of J. Agric. Sci., Mansoura Univ., 2006, 31 (7): 337-358.

[5]Mchinney, L.J., Skinner, D.O., Nable, R.G, Teeter, A., 2001, Pellet quality effects on Broiler growth and efficiency. Animal science research report, Oklahoma Agricultural Experiment Station, Division of Agricultural Science and Natural Resources, Oklahoma state Univ. August 2001: 1086.

[6]Van, T., Vliet, A.F.B., Van der Pole, 2008, The Effects of the diet ingredients and their composition on production characteristics of pellets and their physical quality. Animal Feed Science and Technology, Volume 70, Issues 1–2, January 1998, Pages 5.