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, adelra99@yahoo, 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, 6:1 and 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/cm³ bulk density, 93.21% durability, 49.01N
hardness, 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 erreas 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, hardness 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
pressed by the rollers inside the die holes – the pellets exits from the die.

Table 1. Composition of the experimental ration

<table>
<thead>
<tr>
<th>ingredients</th>
<th>Percentage</th>
<th>Ration formula</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley grains</td>
<td>19.20</td>
<td>Barley grains</td>
<td>19.20</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>28.50</td>
<td>Wheat bran</td>
<td>28.50</td>
</tr>
<tr>
<td>Clover hay</td>
<td>30.90</td>
<td>Clover hay</td>
<td>30.90</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>5.00</td>
<td>Black seed meal</td>
<td>14.13</td>
</tr>
<tr>
<td>Corn grain</td>
<td>11.7</td>
<td>Corn grain</td>
<td>2.57</td>
</tr>
<tr>
<td>Molasses</td>
<td>3.00</td>
<td>Molasses</td>
<td>3.00</td>
</tr>
<tr>
<td>Limestone</td>
<td>1.00</td>
<td>Limestone</td>
<td>1.00</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.25</td>
<td>Sodium chloride</td>
<td>0.25</td>
</tr>
<tr>
<td>Premix</td>
<td>0.30</td>
<td>Premix</td>
<td>0.30</td>
</tr>
<tr>
<td>DL Methionine</td>
<td>0.15</td>
<td>DL Methionine</td>
<td>0.15</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100%</strong></td>
<td><strong>TOTAL</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

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).

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).
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:

\[
\text{Energy consumed} = \frac{P}{Q} = \text{kW.h/ton}
\]

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

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

Where:
\( I \) = Line current strength in amperes.
\( V \) = Potential difference (Voltage) being equal to 380 V.
\( \cos \theta \) = Power factor (being equal to 0.84).
\( \eta \) = 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.
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.

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 5:1 to 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.](image_url)

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 2 min 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 2 min to 3.5 min the bulk 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 2 min to 3.5 min the bulk 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 5 minutes could be due to scattering formula.
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 receptivally, 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 receptivally, 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 receptivally, 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-conditioner retention time of 4.5 min receptivally, 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 hardness

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 respectively.

Using die L/D ratio of 5.5:1 the pre-conditioner retention time increased from 2 min 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 respectively, using die L/D ratio of 6:1 the pre-conditioner retention time increasing from 2 min 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 respectively, 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 respectively, 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.

Regarding for collected data showed in Fig. 10, it indicated that increasing the pre-conditioner retention time from 2 min 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