Zagazig J. Agric. Res., Vol. 36 No. (4) 2009 877-892

EVALUATION OF SOME FODDER PREPARATION EQUIPMENTS UNDER EGYPTIAN CONDITIONS

Ahmed, Taghreed, H., M.S. El-Shal, M.A. Hassan and E.I. Abd El-Aal

Agric. Eng. Dept., Faculty of Agriculture, Zagazig University, Egypt

Accepted 3/8/2009

ABSTRACT: The process of reducing size of the grains by crushing is normal operation in most of poultry farms. The aim of this study is to evaluate the performance of four poultry fodder mix-milling equipments as a sample of private fodder preparation equipments which widely spread in Egypt. This study included equipments productivity, operation efficiency, energy consumed and cost analysis considering economical management.

The obtained results reveal to the following:

- **The highest mix-milling productivity of 11.563Mg/h, 69.379 Mg/day and 10710 Mg/year for hourly, daily and annual productivity respectively under the use of first equipment at 0.7 cm screen hole diameter and ratios of mixing materials for one Mg was (60 % corn – 30 % soybean – 10 % concentrates).**
- **The highest values of operation, daily utilization and annual utilization efficiency were 90, 67.5 and 57.85% respectively under the use of first equipment.**
- **The lowest value of energy consumed of 0.514 kW.h/Mg under the use of forth equipment at 0.7 cm screen hole diameter and ratios of mixing materials per one Mg was (60 % corn – 30 % soybean – 10 % concentrates).**
- **The lowest value of cost of 4.57 and 4.85 LE/Mg under the use of forth and first equipments at screen hole diameter of 0.7 cm.**

Key words: Milling, mixing, fodder, poultry equipments, hammer mill.

INTRODUCTION

Recently poultry production industry in Egypt is considered one of the most. Past experiences demonstrated that the grinding of grains would make fodder tastier and easier access to the digestion and the maximum benefit from the nutritional value of available forage, in addition to the ease of mixing with other feed components. Reece *et al.* (1986) studied the effects of hammer mill screen size on ground corn particle size and stated that energy for hammer grinding of maize could be reduced with 27% by increasing the screen size from 4.76 to 6.35 mm and 35% if mill screen size increased from 4.76 to 7.94 mm. Hassan (1994) modified and evaluated a small locally made mix-milling unit and found that increasing the screen hole diameter of hammer mill from 3.2 to 4.8 and 6.33 mm gave an increase of 18.6 and 68.1% in grinding capacity and a decrease of 30 and 55% in grinding energy under operating conditions at drum speed of 2930 rpm, number of hammers 12 hammers and moisture content 5.1%. Hegazy *et al.* (2002) show that the milling productivity decreased as screen size decrease from 3 to 2 mm and cause a corresponding increase in the milling energy consumed. Lopo (2002) reported that in the forage industry, hammer mills are relatively cheap, easy to operate and produce wide range of particles. El-Ashhab *et al.* (2003) reported that energy required for grinding one Mg of corn kernels was duplicated when replacing the 7.5 mm hole diameter with another one with 3.6 mm hole diameter.

The main objective of this study is to evaluate the performance of four mix-milling equipments in terms of:

1. Equipments productivity.
2. Operation and utilization efficiencies.
3. Energy consumed.
4. Cost analysis considering economical management.

MATERIALS AND METHODS

This study was conducted through 2008 at Taroot, Meet Abo Ali and Kafr Abo El-Zagazig villages at Sharkia Governorate. The experimental work and data collection were carried out to evaluate the performance and management of national mix-milling equipments in different sizes which spreading widely at

Egyptian poultry farms, the equipments shown in Fig. 1 and Table 1.

Measurements and Determinations

The study was conducted to evaluate the equipments under operating conditions of 0.3, 0.5 and 0.7 cm screen hole diameter and three mixing ratios: mixture A (60% corn – 30% soybean – 10% concentrates), mixture B (65% corn- 25% soybean- 10% concentrates) and mixture C (70% corn– 20% soybean– 10% concentrates) by the following indicators:

Equipments productivity

The hourly productivity (Mg/h) of the equipment is the rate of productivity by the amount of actual time consumed in operation (lost and productive time). Lost time is considered as time spends in interruptions, replacing screens and simple repairs.

Daily productivity (Mg/day) estimated as the productivity considering the average of daily time work of the equipments.

Annual productivity (Mg/year) = Average of daily productivity x 6 days x 4 weeks x 12 menthes.

Operation and utilization efficiencies

1- The operation efficiency was calculated as follows:

$$\eta_O = \frac{A.T}{TotalA.T}$$

Where:

η_O = The operation efficiency, %

A.T = Actual time consumed, min/Mg.

Total A.T = Total actual time consumed,min/Mg. (considering time losses).

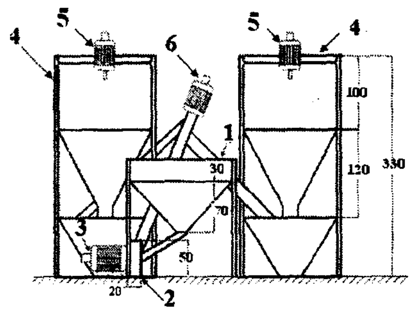
2- The daily utilization efficiency (η_{du}) was calculated as follows:

$$\eta_{du} = \frac{\text{productivity for daily work hours}}{\text{imposed productivity for 8 work hours}}$$

Table1. Equipments specifications

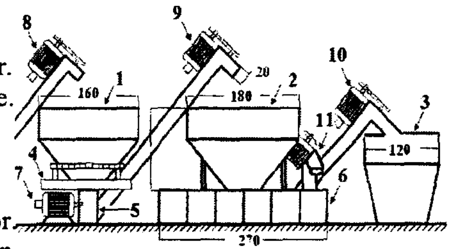
Equipments	Filing system	Milling hopper capacity, Mg	Milling motor, kW	No. of hammers	Hammers speed, rpm	Mixing system
1	manual	1.5	25.7	24 (4 x 6)	3000	vertical
2	automatic	1.5	22	20 (4 x 5)	2980	horizontal
3	manual	1.0	22	20 (4 x 5)	2950	horizontal
4	manual	0.5	7.4	16 (4 x 4)	2840	horizontal

(1) Milling hopper.
(2) Milling chamber
(3) Milling motor.
(4) Mixing hopper.
(5) Mixing motor.
(6) Diversion motor.



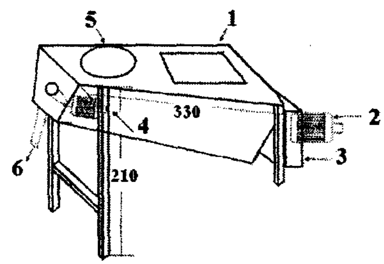
First equipment

1) Milling hopper.
2) Mixing hopper.
3) Concentrates hopper.
4) A peripheral balance.
5) Milling chamber.
6) Mixing chamber.
7) Milling motor.
8) Grains suction motor.
9) Milled grains suction
10) Concentrates suctioı
11) Out put opening.



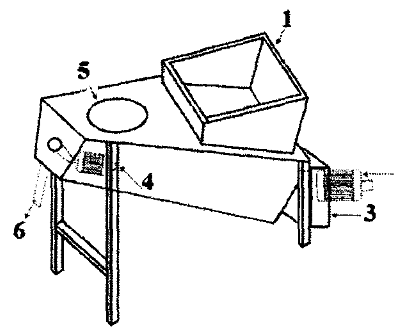
Second equipment

(1) Grains in put opening.
(2) Milling motor.
(3) Milling chamber.
(4) Mixing motor.
(5) Concentrates in put.
(6) Out put opening.



Third equipment

(1) Grains in put opening.
(2) Milling motor.
(3) Milling chamber.
(4) Mixing motor.
(5) Concentrates in put.
(6) Out put opening.



Forth equipment

Fig. 1. Schematics of mix-milling equipments

3- The annual utilization efficiency (η_{au}) was calculated as follows:

$$\eta_{au} = \frac{\text{productivity for year}}{\text{imposed productivity for year}}$$

Where:

Productivity for year = Average of daily productivity x 6 days x 4 weeks x 12 menthes.

Imposed productivity for year = Hourly productivity x 8 work hours x 7 days x 4 weeks x 12 menthes.

Energy consumed

The power consumed (kW) was calculated through the following equation according to Ibrahime (1982)

Total consumed power

$$= \frac{\sqrt{3}\,.\,I.\,V.\,\eta.\,\cos\theta}{1000}$$

Where:

I = line current strength in amperes.

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

η=Mechanical efficiency(95%).

$\cos\theta$= Power factor being equal to (0.84).

The energy consumed in (kW.h/Mg) was calculated by using the following equation:

Energy consumed

$$= \frac{\text{Power consumed (kW)}}{\text{Hourly productivity (Mg/h).}},$$

kW.h/Mg

Cost analysis

The criterion cost required for the mix-milling operation was estimated as fixed and variable costs.

RESULTS AND DISCUSSION

The data were examined to evaluate the performance of the poultry fodder preparation equipments which widely spread and used in this study. Different criteria such as equipment productivity, operation efficiency, daily utilization efficiency, annual utilization efficiency, energy consumed and cost analysis.

The Obtained Results will be Discussed under the Following Items

Equipments productivity

Hourly productivity

Data of hourly productivity versus equipments size, number of hammers and filling system and under the experimental operating conditions of ratios of mixing materials and screen hole diameter given in Fig. 2.

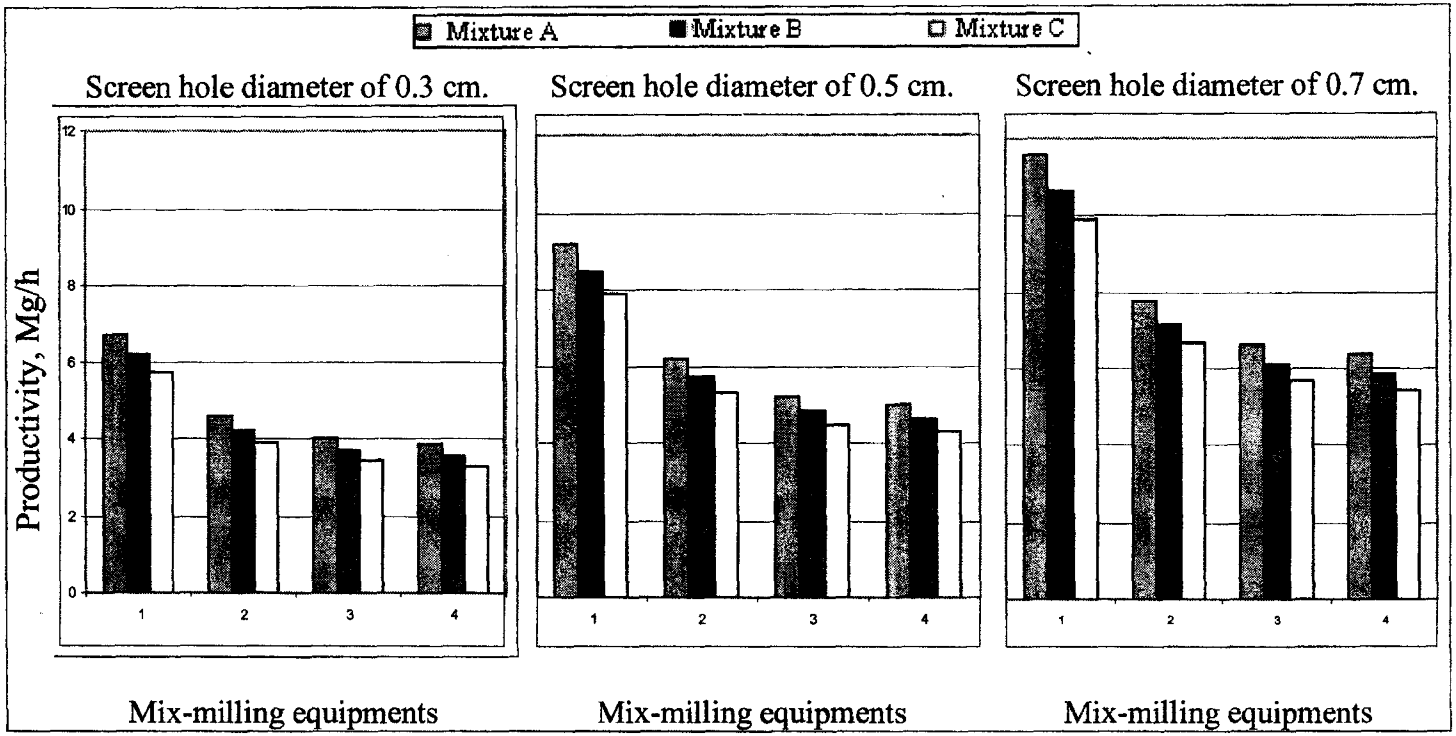


Fig. 2. Hourly productivity of mix-milling equipments at different screen hole diameter and different ratios of mixing materials

Data obtained showed that at screen hole diameter of 0.3 cm, increasing corn ratio in mixing materials from 60 to 65 and 70 % decreased productivity from 6.692 to 6.171 and 5.732 Mg/h for first equipment; from 4.566 to 4.215 and 3.915 Mg/h for second equipment; from 4.010 to 3.704 and 3.440 Mg/h for third equipment; from 3.846 to 3.549 and 3.297 Mg/h for forth equipment. At screen hole diameter of 0.5 cm hourly productivity decreased from 9.194 to 8.485 and 7.879 Mg/h for first equipment; from 6.164 to 5.690 and 5.283 Mg/h for second equipment; from 5.216 to 4.814 and 4.471 Mg/h for third equipment; from 5 to 4.613 and 4.286 Mg/h for forth equipment. At screen hole diameter of 0.7 cm productivity decreased from 11.563 to 10.658 and 9.908 Mg/h for first equipment; from 7.764 to 7.166 and 6.658 Mg/h for second equipment; from 6.618 to 6.111 and 5.696 Mg/h for third equipment; from 6.347 to 5.855 and 5.435 Mg/h for forth equipment.

The decrease in productivity for mix-milling operation due to increasing corn ratio in mixing materials and decreasing of screen hole diameter for first, second, third and forth equipments attributed to increasing of actual time that required for the mix-milling operation as well as wide variation in time lost in filling milling hopper relating to system of filling, number of workers, replacing screen and repairs and maintenance.

Daily productivity

Data given in Fig. 3 showed that at screen hole diameter of 0.3 cm, increasing corn ratio in mixing materials from 60 to 65 and 70 % decreased daily productivity from 40.149 to 37.028 and 34.393 Mg/day for first equipment; from 18.263 to 16.860 and 15.660 Mg/day for second equipment; from 16.041 to 14.418 and 13.761 Mg/day for third equipment; from 15.384 to 14.196 and 13.188 Mg/day for forth equipment. At screen hole diameter of 0.5 cm daily productivity decreased from 55.161 to 50.910 and 47.272 Mg/day for first equipment; from 24.657 to 22.760 and 21.133 Mg/day for second equipment; from 20.862 to 19.256 and 17.883 Mg/day for third equipment; from 20.001 to 18.453 and 17.142 Mg/day for forth equipment. At screen hole diameter of 0.7 cm daily productivity.

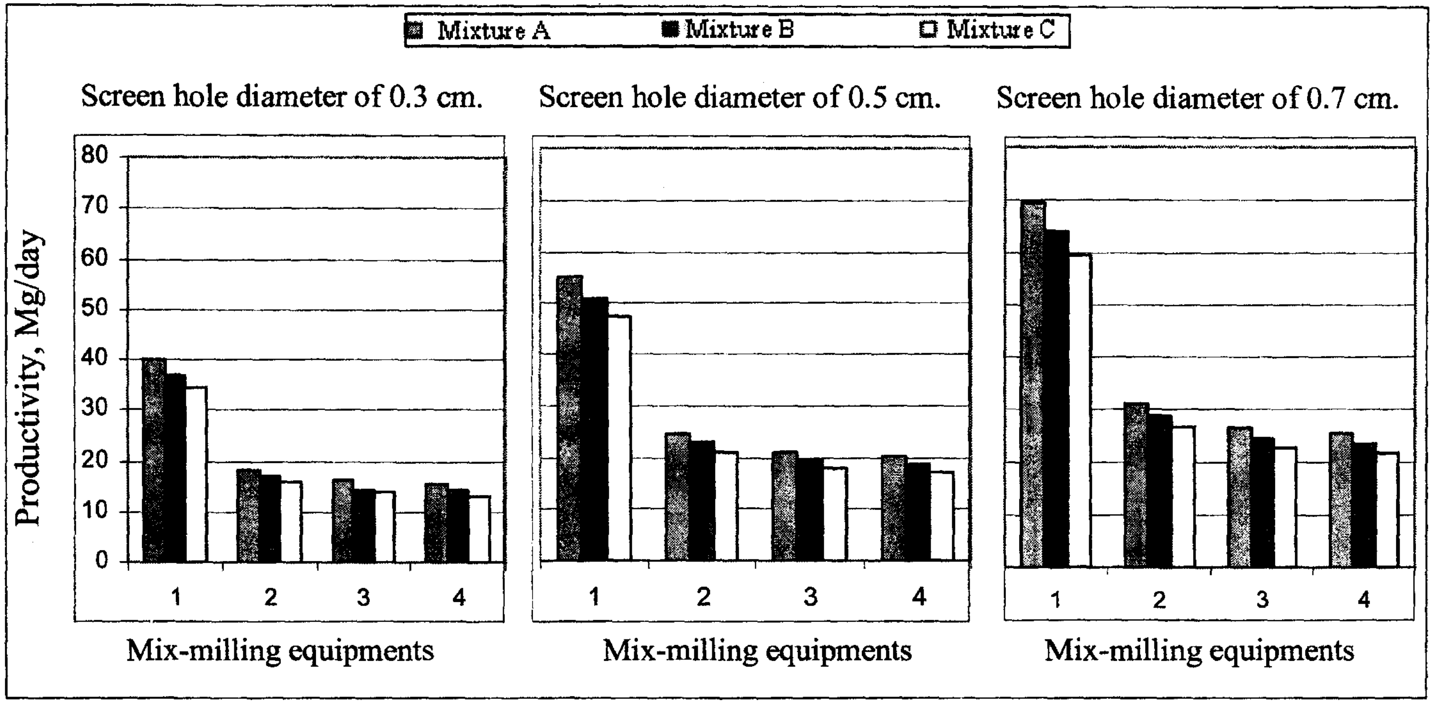


Fig. 3. Daily productivity of mix-milling equipments at different screen hole diameter and different ratios of mixing materials

from 69.379 to 63.947 and 59.449 Mg/day for first equipment; from 31.057 to 28.663 and 26.630 Mg/day for second equipment; from 26.472 to 24.444 and 22.785 Mg/day for third equipment; from 25.389 to 23.421 and 21.738 Mg/day for forth equipment considering average of daily working time 6 hours per day for first equipment and 4 hours per day for second, third and forth equipments.

Annual productivity

Data in Fig. 4 shows the average of annual productivity of the equipments under study at the previous operating conditions and number of yearly working days were 288 day, the annual productivity were 10710, 4875, 4283 and 4105 Mg/year. These values considered very low compared with the imposed values if the equipments work 8 hours in 336 day per year.

It can be concluded that the decrease in productivity for mix-milling operation due to increasing corn ratio in mixing materials and decreasing of screen hole diameter for first, second, third and forth equipments was attributed to increasing of actual time that required for the mix-milling operation as well as wide variation in time lost in filling milling hopper relating to system of filling, number of workers, replacing screen and repairs and maintenance. Also the variation in daily actual time of several equipments emphasizes the high difference of daily productivity.

Operation and utilization efficiency

Representative values of mix-milling operation, daily utilization and annual utilization efficiency versus productivity considering time losses are given in Fig. 5.

The average of operation efficiency was 89.9, 83.3, 75.0 and 74.9 % for first, second, third and forth equipments respectively. Results show that the average of daily utilization efficiency was 67.5, 41.7, 37.5 and 37.5 % for first, second, third and forth equipments respectively. Concerning the average of annual utilization efficiency was 57.9, 35.7, 32.1 and 32.1 % for first, second, third and forth equipments respectively.

The decrease of efficiency for different equipments attributed to the larger values of actual time required for the mix-milling operation as well as for minor repairs and maintenance.

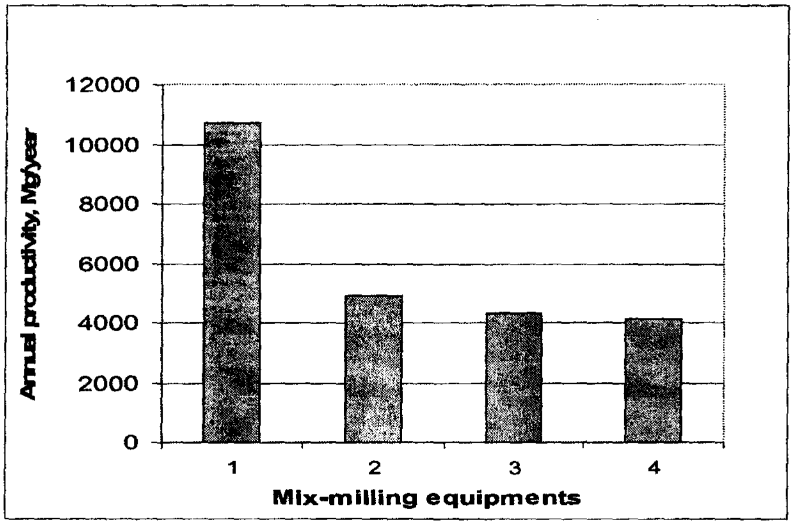


Fig. 4. Average of annual productivity of mix-milling equipments

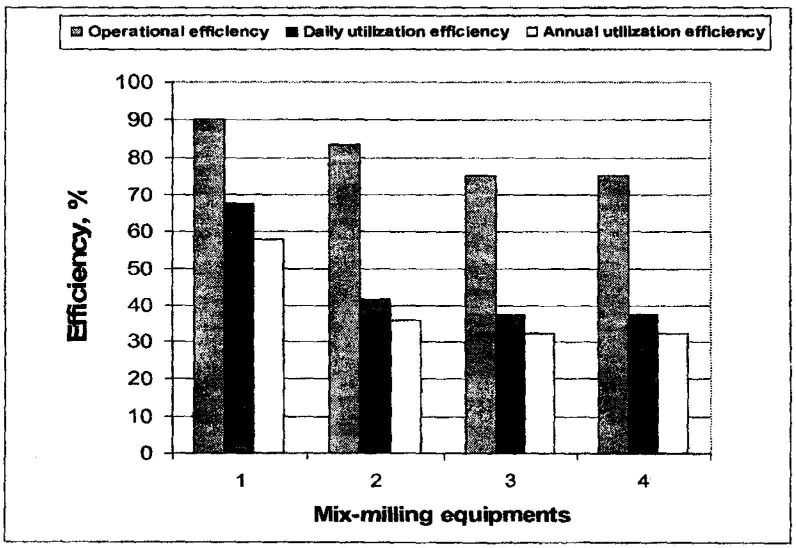


Fig. 5. Average of operation, daily utilization and annual utilization efficiency.

Energy consumed

Energy consumed for mix-milling operation are related to the ratios of mixing materials as well as the screen hole diameter as shown in Fig. (6).

Relating to first equipment, decreasing corn ratio from 70 to 65 and 60 % per one Mg of mixed poultry fodder materials decreased energy consumed from 1.770 to 1.645 and 1.517 kW.h/Mg at screen hole diameter of 0.3 cm; from 1.100 to 1.116 and 0.943 kW.h/Mg at screen hole diameter of 0.5 cm; from 0.823 to 0.765 and 0.705 kW.h/Mg at screen hole diameter of 0.7 cm; from 2.469 to 2.294 and 2.112 kW.h/Mg at screen hole diameter of 0.3 cm; from 1.617 to 1.552 and 1.433 kW.h/Mg at screen hole diameter of 0.5 cm; from 1.200 to 1.115 and 1.029 kW.h/Mg at screen hole diameter of 0.7 cm for second equipment; from 1.831 to 1.701 and 1.571 kW.h/Mg at screen hole diameter of 0.3 cm; from 1.221 to 1.134 and 1.047 kW.h/Mg at 0.5 cm of screen hole diameter; from 0.811 to 0.756 and 0.698 kW.h/Mg at 0.7cm of screen hole diameter for third equipment; from 1.449 to 1.347 and 1.243 kW.h/Mg at screen hole diameter of 0.3 cm; from 0.943 to 0.876 and 0.808 kW.h/Mg at 0.5 cm of screen hole diameter; from 0.599 to 0.557 and 0.514 kW.h/Mg at 0.7cm of screen hole diameter for forth equipment.

In addition it is observed that the highest values of energy consumed achieved by second equipment related to the presence of an excessive suction motor to withdraw corn grains from silo instead of manual filling by labors.

Cost analysis

A complete cost analysis was made at different operating conditions and related with productivity for mix-milling equipments. The resulting operating cost was found to be affected by both equipments size and power.

To be more accurate, cost analysis was used as an important indicator for selecting optimum equipment size suited for certain number of served farms.

Influence of screen hole diameter on mix-milling operation cost

Representative values of mix-milling operation cost versus specifications of equipments size, number of hammers, filling system and addition of suction motors and under the experimental operating conditions of screen hole diameter are given in Fig. (7).

The obtained data show that increasing screen hole diameter from 0.3 to 0.5 and 0.7 cm decreased operation cost from 8.49 to 6.13 and 4.85 LE/Mg for first equipment; from 13.86 to 10.22 and 8.08 LE/Mg for second equipment; from 8.61 to 6.57 and 5.13 LE/Mg for third equipment; from 7.69 to 5.86 and 4.58 LE/Mg for forth equipment.

The major reason for the increase of cost with small screen hole diameter by different equipments was attributed to both excessive time and power consumed.

Influence of corn ratio in mixing materials on mix-milling operation cost

The obtained results showed that decreasing corn ratio in mixing materials decreased costs as shown in Fig. (8).

Decreasing corn ratio in mixing materials from 70 to 65 and 60 % decreased average of operation cost at 0.3, 0.5 and 0.7 cm of screen hole diameter for mix-milling operation from 6.67 to 6.20 and 5.71 LE/Mg for first equipment; from 11.05 to 10.26 and 9.47 LE/Mg for second equipment; from 7.00 to 6.51 and 6.01 LE/Mg for third equipment; from 6.26 to 5.81 and 5.36 LE/Mg for forth equipment.

The obtained data show that the actual numbers of served farms by first, second, third, forth and fifth equipments were 109, 50, 43, 42 and 26 respectively. These values considered very low compared with the economical number of served farms if the equipments work 8 hours in 336 day per year, the economical number of served farms would be 189, 140, 136, 130 and 91farms first, second, third, forth and fifth equipments respectively.

Economical number of served farms

Representative values of both actual number of served farms (farm capacity = 5000 broiler, farm requirements of fodder = 90 Mg / year) and imposed number of served farms by different equipments are given in Fig. (9).

The obtained data show that the actual numbers of served farms by first, second, third and forth equipments were 109, 50, 43 and 42 respectively. These values considered very low compared

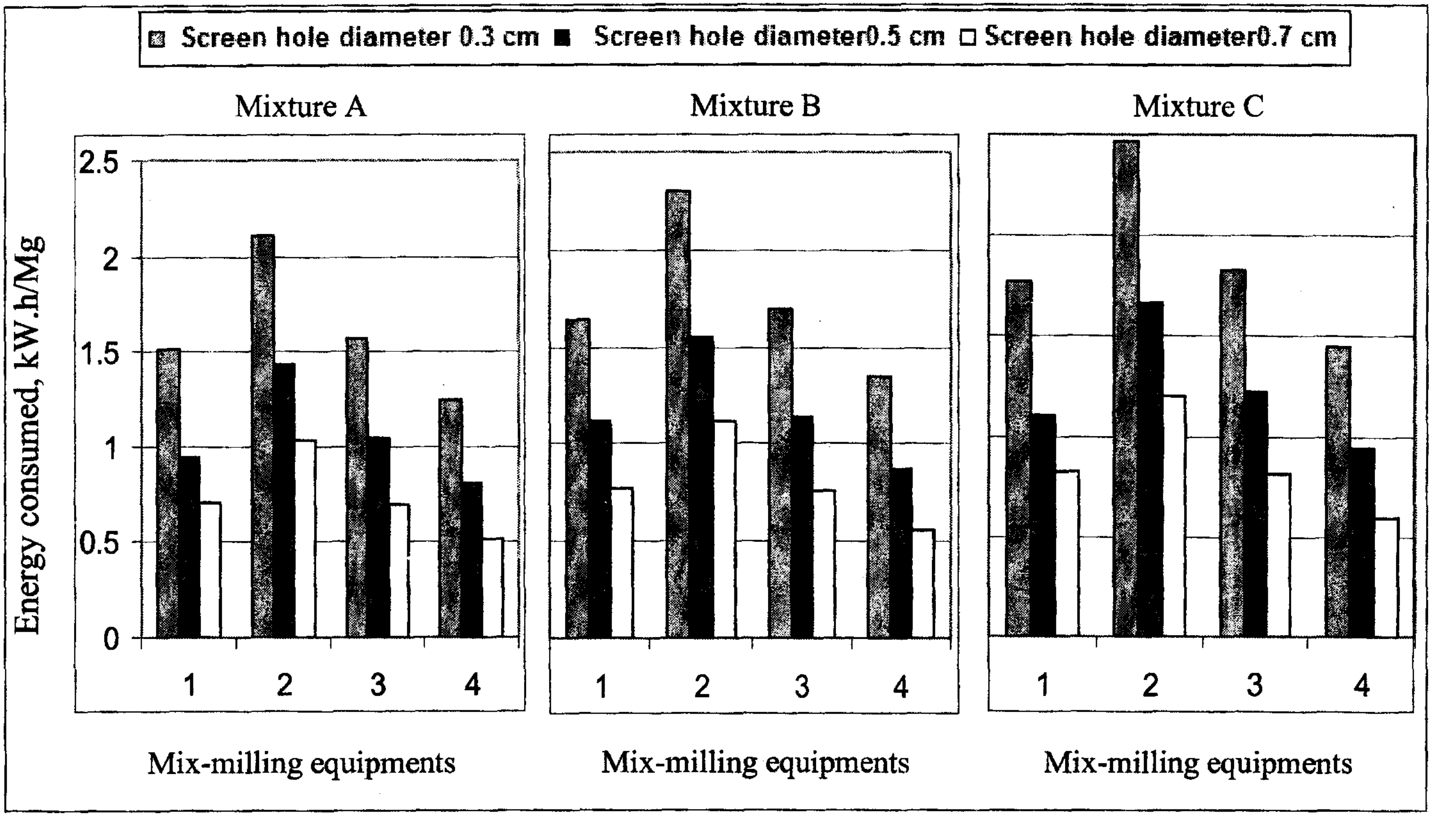


Fig. 6. Energy consumed for mix-milling operation at different screen hole diameter and different ratios of mixing materials

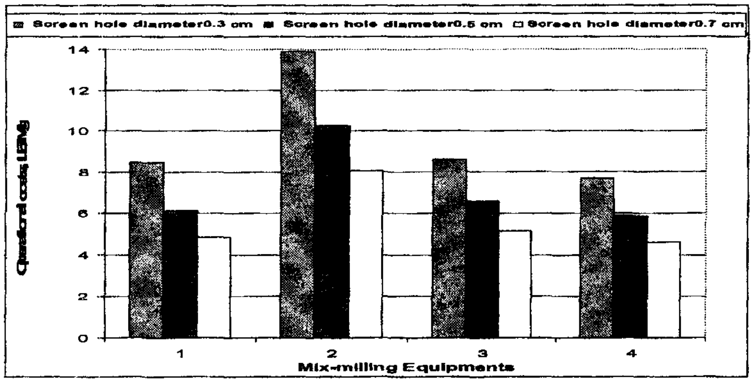


Fig. 7. Influence of screen hole diameter on mix-milling operation cost

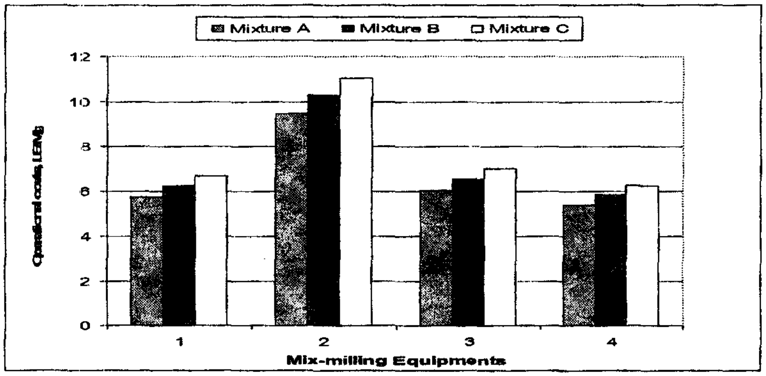


Fig. 8. Influence of materials ratios on mix-milling operation cost

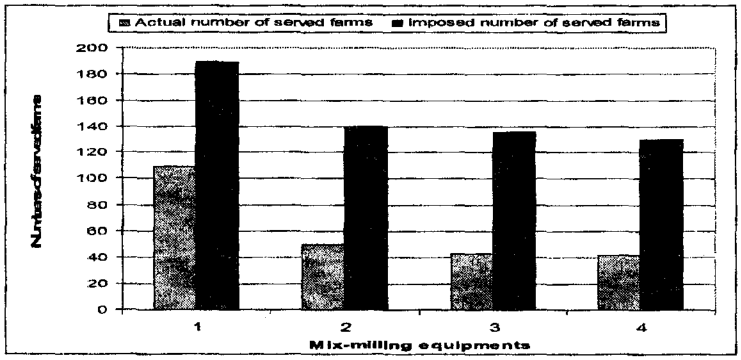


Fig.9. Actual and imposed numbers of served farms by different equipments

with the economical number of served farms if the equipments work 8 hours in 336 day per year, the economical number of served farms would be 189, 140, 136 and 130 farms by first, second, third and forth equipments respectively.

Conclusion

From the previous discussions, it can be concluded that:

1. First equipment of largest size achieved the highest productivity and efficiency.
2. Increasing screen hole diameter increases productivity and operational efficiency but decreasing energy consumed and costs of mix-milling operation.
3. Decreasing corn ratio in mixing materials increasing productivity and operational efficiency but decreasing energy consumed and costs of mix-milling operation.

Finally it is recommended to make study about the number of farms which would be served to select the optimum size of the equipment.

REFERENCES

El-Ashhab, A.O.M., B.A. Hemeda, H.A. Radwan and T.A.A. Deraz. 2003. Minimizing energy required to grind some grains for feed rations. Egyptian J. Nutrition and Feeds (2003) 6 (Special Issue): 1325-1333.

Ibrahim, M.K.E. 1982. Wet milling wheat grain. M. Sc. Th., Fac. of Agric. Mansoura Univ.: 64-65.

Hassan, M.A. 1994. Modifying and evaluating small locally made mix-milling unit suitable for Egyptian poultry farms. Misr. J. Ag. Eng. Vol.11, No. (2) pp.569-584.

Hegazy, K.E.S., A.O.M. El-Ashhab, B.A. Hemeda and Mosa. M.A. Magda. 2002. Preparation and conversion of eggshell as hatchery by-product wastes to produce untraditional poultry feeds. Misr. J. Ag. Eng. Vol. 19, No. (2) pp.958-972.

Lopo, P. 2002. The right grinding solution for you: roll, horizontal or vertical. Feed Management 53 3 (2002), pp. 23–26.

Reece, F.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. Poultry Sci., 65: 1257-1261.

تقييم بعض معدات تجهيز الأعلاف تحت الظروف المصرية

تغريد حبشى أحمد – محمـــد سعـــد الـــدين الشال

محمود عبد العزيز حسن– السادات إبراهيم عبد العال

قسم الهندسة الزراعية – كلية الزراعة – جامعة الزقازيق

أجريت هذه الدراسة فى قرى طاروط و ميت أبوعلى و كفر أبو الزقازيق فى محافظـــة الشرقية خلال عام ٢٠٠٨ بهدف تقييم أداء أربع معدات جرش و خلط لتجهيـــز الأعـــلاف. وكانت المعدات المستخدمة هي: المعدة الأولى بها وحدة جرش سعة القـــادوس ١,٥ ميجـــا جرام غرفة الجرش بها ٢٤ سكين على عمود يدور بسرعة ٣٠٠٠ لفة/دقيقة، ووحدة خلط عبارة عن خلاطين رأسيين. المعدة الثانية بها وحدة جرش سعة القادوس ١,٥ ميجا جـــرام غرفة الجرش بها ٢٠ سكين على عمود يدور بسرعة ٢٩٨٠ لفة/دقيقة، ووحدة خلط عبارة عن خلاط أفقى. المعدة الثالثة بها وحدة جرش سعة القادوس ١ ميجا جرام غرفة الجـــرش بها ٢٠ سكين على عمود يدور بسرعة ٢٩٥٠ لفة /دقيقة، ووحدة خلط عبارة عن خـــلاط أفقى. المعدة الرابعة بها وحدة جرش سعة القادوس ٠,٥ ميجا جرام غرفة الجرش بها ١٦ سكين على عمود يدور بسرعة ٢٨٤٠ لفة/دقيقة، ووحدة خلط عبارة عن خلاط أفقى. وقد تم أخذ المؤشرات الآتية فى الاعتبار (إنتاجية المعدة فى الـــساعة – الإنتاجيـــة اليوميـــة – الإنتاجيةالسنوية – كفاءة عملية الجرش والخلط – كفاءة الاستخدام اليـــومى والـــسنوى – الطاقة المستهلكة – تكاليف عملية الجرش والخلط).

وأوضحت النتائج مايلى:

١- أعلى إنتاجية هى ١١,٥٦٣ ميجا جرام /ســـاعة و ٦٩,٣٧٩ ميجـــا جـــرام /يـــوم و ١٠٧١٠ ميجا جرام /سنة على الترتيب عند استخدام المعدة الأولى عندما كـــان قطـــر فتحة الغربال ٠,٧ سم ونسبة الخلط (٦٠ % ذرة + ٣٠ % صويا + ١٠ % مركزات).

٢- أعلى قيمة لكفاءة التشغيل وكفاءة الاستخدام اليـــومى والـــسنوى هـــى ٩٠، ٦٧,٥ و ٥٧,٨٥% على الترتيب عند استخدام المعدة الأولى.

٣- أقل قيمة للطاقة المستهلكة هى ٠,٥١٤ ك وات. ساعة/ ميجا جرام عند استخدام المعدة الأولى عندما كان قطر فتحة الغربال ٠,٧ سم ونـــسبة الخلـــط (٦٠ % ذرة + ٣٠ % صويا + ١٠ % مركزات).

٤- أقل قيمة لمتوسط التكاليف الكلية هى ٤,٤٧ و٤,٨٥ جنيه/ ميجا جرام عنـــد اســـتخدام المعدة الرابعة و المعدة الأولى على الترتيب.