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분말사료와 Pallet 사료의 생산비 비교

박경규 · D. S. Chung * · K. Behnke * · 김인수 **

경북대학교 농과대학 농공학과 · * Kansas 주립대 농공학과
** 경북대학교 자연과학대학 유전공학과

Comparison of Mash and Pelleting Feed Production Cost.

Park, Kyung Kyu · D. S. Chung* · K. Behnke* · Kim, In Soo**

Dept. of Agricultural Engineering, Coll. of Agric., Kyungpook Natl. Univ.
*Dept. of Agricultural Engineering, Kansas State Univ., U. S. A.
** Dept. of Gentic Engineering, Coll. of Natural Sci., Kyungpook Natl. Univ.

Summary

In an attempt to compare the mash and pelleting costs, individual production costs of eash mash and pelleting are analyzed.

For the analysis, Park's model (1982) are used. According to the results of the analysis, the following conclusions are made.

1. Total energy cost for pelleting is 4 times higher than that for mash feed production.
2. Labor cost for pelleting is 20 % higher than that of mash feed.
3. Capital requirements for pelleting feed mill is approximately 20 % higher than that for mash feed mill when feed mill size is 200 ton/day.
4. Total production cost for pelleting is from 30 % to 50 % higher than that for mash feed when mill size ranges from 100 ton/day to 400 ton/day.

Introduction

The type of feed can be classified as mash, pellet, blocks and liquids. Also, these type of feed can be subdivided as bulk and bagged feed. Pelleting feed has a lot of advantage compare with mash feed, such as feeding value ; handling properties ; reduced segregation ; less dust ; uniformity of material ; and ability to add liquids to feeds.

Many studies have been reported that pelleting feed is superior to mash feed in terms of feeding value. unfortunately, the value of most of these benifits, in terms of dollars is not well defined or documented. However, Mc Ellhiney (1982) believes that at least 5-10% improvement in feed conversion can be expected in most classes of livestock with the feeding of pelleting rations.

The problem of pelleting lies in its high production cost compare with that of mash feed. In order to produce pelleted feed, there is more involed than just buying and installing a pelleting system. Additional building and bin space must be provided, a boiler or additional steam generating capacity is required, and electrical switch gear must be "beefed up" to handle the additional motor load. Also, additional labor and energy costs should be added up.

Figure 1 shows the additional process for pelleting and Table 1 describes the typical pelleting equipment and facilities when production capacity is

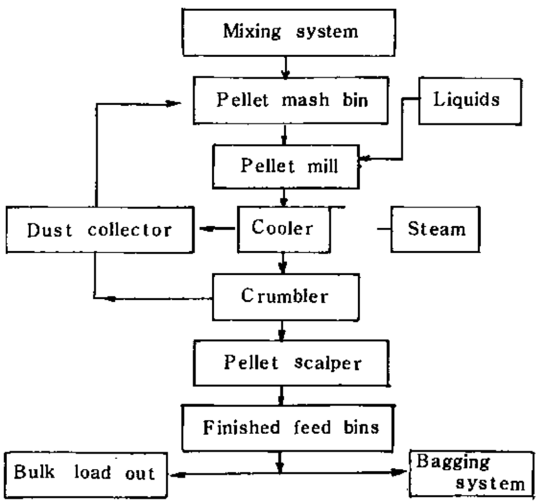

Fig. 1. Process flow diagram of pelleting system.

100 ton/day.

Mc Ellhiney (1980) comments about pelleting and mash production costs under a certain condition.

However, no one has completely compared pelleting and mash production so far, because so may factors are involved.

In order to analyze the production cost, many

Table 1. Equipment and facilities for Pelleting system

Item	No.	Price (dollars)
Pellet sureg bin	2	20,000
Pellet mill	1	61,465
Horizontal cooler	1	32,901
Dust collector and fan	1	5,598
Crumbler	1	18,906
Drag conveyor	2	2,448
Bucket elevator	1	11,240
Pellet cleaner	1	17,218
Swing spout distributor	1	4,319
Boiler system	1	22,543
Miscellaneous		20,000
Total		217,448

mathematical models, such as energy consumption, labor requirement and capital requirement, should be developed as functions of mill capacity and % of pellet production. However, much time and efforts are required for developing these models. Fortunately, Park (1982) developed all of these models. Thus, the objective of the study is to compare production costs of both pelleting and mash feeds by analyzing individual costs in a feed mill, based on Park's results.

Methods and Assumptions

Batch type swine and poultry feed mills are selected which are already developed as a model mill by a computer program (Park, 1982). Energy consumption, labor requirements, and capital requirements are analyzed as a function of feed mill capacity. Also, fixed cost and variable cost are analyzed. Fixed costs includes depreciation, administrative costs, taxes, insurance and interests. Variable costs consist of labor, energy, repair and maintenance, and supplies and miscellaneous costs. Capacity of model mills ranges from 10 ton/hr to 50 ton/hr. For the simplicity, model mill produces 50% bulk and 50% package, respectively, since whether packages or not has little bearing on the cost differential between mash and pelleted feed.

Costs Analysis

1. Energy costs

Electrical energy, boiler fuel energy and vehicle fuel energy are used for feed production. Electrical energy consumption model (Park, 1982) as functions of mill capacity and fraction of pellet production rate is presented in Equation 1 and Figure 2.

$$Ee = 6.71 + 10.21\,R + \frac{330.4}{x} \quad (1)$$

Where Ee = electrical energy usage, Kwh/ton

R = Fraction of pelleting production, decimal.

X = Daily production rate based on 1-shift operation a day, ton/day.

Data for boiler fuel usage is provided by boiler manufacturer, and it is explained in terms of boiler horsepower. Boiler horsepower is determined by oversizing the boiler by 30% after the steam requirement for pelleting is adequately calculated (AFMA Energy Committee, 1980). Based on the required boiler horsepower model (Park, 1982), the mathematical model for boiler fuel consumption is formulated and presented in Equation 2.

$$E_B = BHP \times (1 + \phi) \times GPH \times 8 \quad (2)$$

where B_B = boiler fuel consumption, gal/day

BHP = required theoritical boiler horsepower (AFMA Energy committee, 1980).

ϕ = Coefficient for additional required boiler horse power for tank heating, space heating and other miscellaneous uses of steam in a feed mill (as a general, 0.3 is accepted).

Front end loaders, fork lift trucks, company operated rail car movers and yard tractors for moving bulk feed trailers are the kinds of vehicles used in feed mills. However, these vehicles usages are not a function of pelleting production but a function of bulk and bagging operation. Thus, by assuming that the model mill produces 50% bulk and 50% bagging feed as mentioned in previous section, vehicle fuel energy usage model (Park, 1982) is developed and presented in Equatinn 3.

$$Ev = \frac{2X(0.5 + RBI)FG}{(60\,FT/TC)} \quad (3)$$

Where Ev = Vehich fuel energy usage, gal/ton

RBI = The ratio of bagged inbound material to total inbound material (approximately 30% in the USA feed industry).

FG = The average forklift truck fuel consumption rate, gal/hr (approximately 1.6 gal/hr of gasoline is consumed by 3000 1b capacity truck (Mc Ellhiney, 1981).

TC = Average required time for 1 cycle operation for the forklift truck [4 min is assumed (McEllhiney, 1981)].

FT = The average capacity of the forklift truck per one cycle operation [1 ton/cycle is assumed (McEllhiney, 1981)].

By combining electrical energy usage, boiler fuel energy usage and vehicle fuel energy consumption, and by considering their unit costs, total energy cost for feed production is presented in Table 2.

According to the Figure 2, electrical energy costs for pelleting is twice more than that for mash

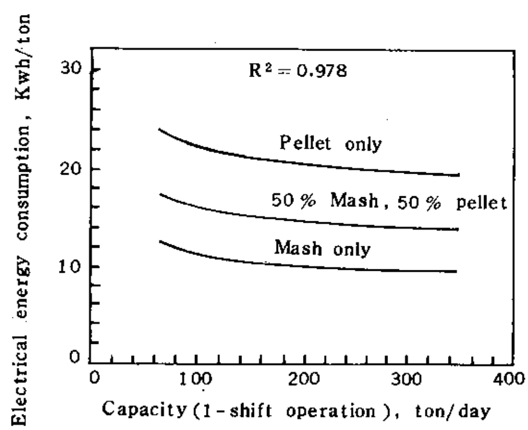

Fig. 2. Electrical energy usage in swine and poultry feed mill.

production. Also, Table 3 shows that total energy costs for pelleting is 4 times higher than that for mash feed production.

2. Labor costs

Labor is functions of a feed mill capacity and the production ratio of each type of finished feed to the total feed production. These labor requir-

Table 2. Total energy costs of pelleting and mash feed

% of pellet production	Plant capacity, ton/day			
	100	200	300	400
0	1/ 0.95	0.85	0.82	0.81
	2/ 911	778	734	712
50	1/ 2.40	2.30	2.28	2.27
	2/ 2217	2095	2050	2028
100	1 4.01	3.91	3.88	3.86
	2/ 3542	3410	3367	3345

1/ dollars / ton

2/ won / ton

ements were reported by Vosloh (1976). Park (1982) developed mathematical model besed on these data. Figure 3 shows labor requirement and Table 4 presents the labor cost for pelleting and mash feed production, respectively. The results indicate that pelleting production cost is approximately 20% higher than that of mash feed. Note that the data of labor wages quoted are provided by a commercial feed mill based on May 1981 present.

3. Capital requirement

Numerous factors are involved for plant investment cost. However, major factors to be considered are the size of mill ; the type of equipment and its installation ; kinds and types of feed to be produced ; the location of plant to be built ; land price ; and the type of building and its construction cost. All feed manufacturers do not have the same basic requirements nor do they have the same amount of capital requirement. Usually, the decision of the factor is a compromise between what the future owner believes is needed, and what the available capital will allow. Park (1982) developed mathematical model for capital requirement as functions of mill capacity and ratio of each type of finished feed production to total feed production. Figure 4 shows the capital requirements as functions of mill capacity and fraction of pellet production.

It indicates that the capital requirements for pelleting feed mill is approximately 20% higher than that for mash feed mill when feed mill size is 200

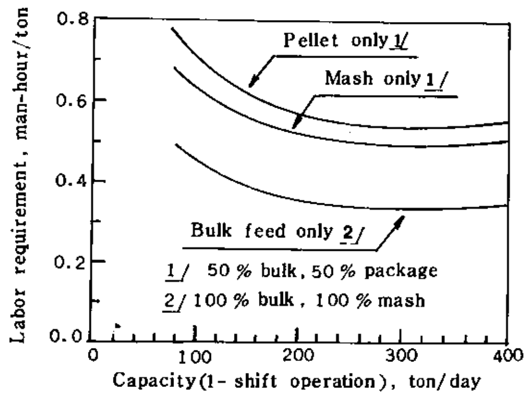

Fig. 3. Labor requirement vs. capcity of plant

Table 3. Labor costs for pelleting and mash feed production

Unit : dollars / ton

% of pellet Production		Plant capacity, ton/day			
		100	200	300	400
0	1/	4.59	3.73	3.43	3.36
50	1/	5.14	4.12	3.83	3.71
100	1/	5.54	4.48	4.19	4.09
0	2/	3.02	2.27	2.06	1.99

1/ 50% bulk and 50% bagging feed.

2/ 100% bulk feed.

ton/day.

4. Depreciation

Physical assets decrease in value with age which may be due to physical deterioration, technological advances, economic changes, or other factors that ultimately will cause retirement of the property. The reduction in value due to any of these causes is a measure of depreciation.

Rates for determining annual depreciation costs vary widely. Most of the equipment may have a useful life of 10 to 20 years. The Internal

Revenue Service provides a guide whereby facilities in the feed industry could be depreciated over a period of 25 years to 50 years. In this model, the equipment and buildings were depreciated by using the straight line method over a 20 year periods.

$$DP = CI / (260 \times 20) \quad (4)$$

where DP = depreciation cost, dollars/ton.

CI = capital requirement, dollars/ton.

5. Administrative cost

General management, ingredient purchasing, nutrition formulation and quality control, typing and book keeping are administrative duties. These functions are usually performed during the day. Vosloh (1976) estimated this cost by assuming a fixed cost per ton for each particular size and type of model mill. He assumed that the cost per ton is the same regardless of variations in the method of operations. These costs are presented in Table 5 (Vosloh, 1976).

$$A_1 = \delta (1.18 - 0.00139 X), \quad R^2 = 0.950$$

where A_1 = administrative cost, dollars/ton.

X = production rate of a plant based on 1 shift operation, ton/day.

δ = 1.58, a coefficient of inflation rate between 1976 and 1981.
This coefficient is derived from the consumer price index rate (USDC, 1981).

6. Taxes

Taxes vary widely from one locality to another. In this model, taxes are derived by taking 35 % of the initial investment as the assessed value and then applying in a 1 % annual rate to this assessment (Vosloh, 1976).

$$Tx = 0.0035 CI / 260 \quad (6)$$

where Tx = Taxes cost, dollars/ton.

CI = Mathematical model for capital investment, dollars/ton.

7. Insurance

The annual insurance cost for an ordinary industrial concern is approximately 1 % of the capital investment (Vosloh, 1976). Despite the fact that insurance costs may represent only a small fraction of the total cost, it is necessary to consider the insurance requirement carefully that the economical

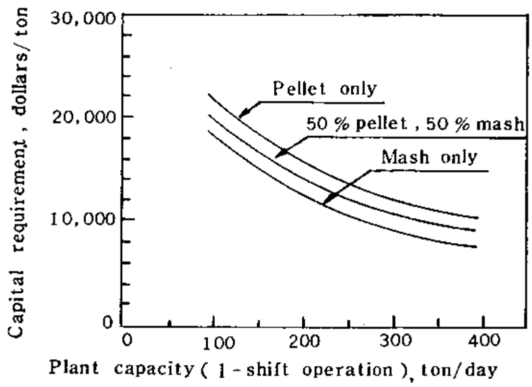

Fig. 4. Capital requirements for swine and poultry feed mill.

operation of a plant is protected against emergencies or unforseen developments.

$$Is = 0.01 CI / 260 \quad (7)$$

where Is = insurance cost, dollars/ton.

8. Interest

The annual interest cost is estimated by applying 4.5 % (one half the normal interest rate of 9 %) times the total capital investment in equipment and facilities (Vosloh, 1976).

$$Ins = 0.045 CI / 260 \quad (8)$$

where Ins = interest costs, dollars/ton.

9. Maintenance and repair cost

Costs of maintenance and replacement parts for equipment as well as the services hired by the mill

Table 4. Administrative cost per ton for each particular size of mill.

Size, ton/day	48	64	80	144	200	240	344	400
Cost, dollars/ton	1.14	1.14	1.14	1.05	0.92	0.89	0.73	0.65

to make repairs are variable. They are assumed to be about 5.5 % of the total investment cost over the long run.

$$Mtc = 0.055\ CI / 260 \quad (9)$$

where Mtc = maintenance and repair cost, dollars/ton.

10. Supplies and miscellaneous costs

This cost includes a number of items which are generally used throughout the plant and pertain to the entire production operation. Vosloh (1976) obtained a cost estimate relating to this category from industry. It is approximately 0.55 dollars per ton by considering the consumer price index.

Results and discussion

By combining all of the individual costs for feed production as analyzed in the previous section, total production costs for pelleting and mash can be estimated as a function of feed production capacity. Table 6 shows total items used for cost estimation and Table 7 and Figure 5 present the total production cost for pelleting and mash feed. This result indicates that the total production cost for pelleting is 30 ~ 50 % higher than that for mash feed when feed mill size ranges from 100 ton/day to 400 ton/day.

In an attempt to make the conclusion whethen pelleting is profitable or not, the following unequality equation is derived. If the Equation 10 is satisfied, then pelleted feed is worth to produce.

$$\frac{Pcp - Pcm + Prp - Prm}{Igc + Pcm + Prm} > Fe \quad (10)$$

where Pcp = Pelleted feed production cost, dollars/ton.

Pcm = mash feed production, dollars/ton.

Igc = price of ingredients, dollars/ton.

Prp = Profit of pelleted feed, dollars/ton

Prm = Profit of mash feed, dollars/ton.

Fe = Benifits of pelleting (decimal)

However, Fe is still remained as an unknown value in terms of dollars. Thus, the question whether pelleted feed is benifit or not is still hard to anwer.

Table 5. Total items used for cost estimation

Fixed costs	Variable costs
Depreciation	Energy costs
Administrative costs	Labor costs
Insurance	Maintenance and repair
Taxes	
Interest	
Supplies and miscellaneous	

Table 6. Comparison of pelleting and mash feed production costs

% of pellet production	Plant capacity, ton/day			
	100	200	300	400
0	17.94	12.71	10.70	9.66
100	23.71	18.13	15.79	14.43
Comparison	5.77	5.42	5.09	4.77
	32.0 %	42.6 %	47.5 %	49.4 %

Unit : dollars/ton

적 요

양계 및 양돈용 배합사료중 pellet사료와 분말사료의 생산비를 비교하였다.

비교분석을 위하여 박(1982)이 개발한 모형을 이용하였으며 공장의 규모는 일산 80ton으로부터 400ton이었다.

분석된 결과를 요약하면 다음과 같다.

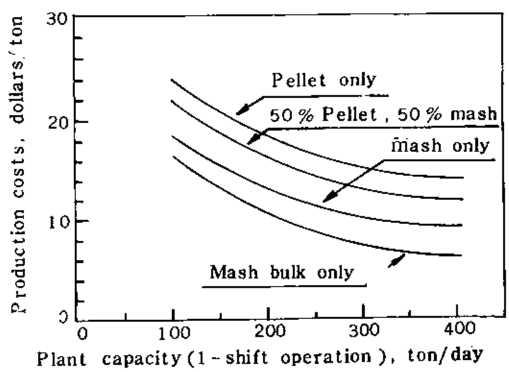

Fig. 5. Total production costs for swine and poultry feed mill.

1. 동력비는 pellet 사료가 분말사료에 비해 4배가 높았다.

2. 노동비는 pellet 사료가 분말사료에 비해 20 %가 높았다.

3. 일산 200 ton 규모의 경우 투자비용은 pellet사료가 20 % 높았다.

4. 고정비 및 변동비를 고려한 총생산비를 공장규모가 100 ton에서 400 ton으로 커질 경우 pellet사료가 분말사료에 비해 30 %에서 50 %로 증가되었다.

References

1. AFMA. 1976. Feed manufacturing technology, AFMA. Arlington Va.
2. AFMA Energy Committee. 1980. Energy management for the feed industry, AFMA Arlingtgon, Va.
3. Butler Manufacturing Co. 1979. Butler Agri-Porduct division, BMA tower, P. O. Box 917, Kansas city, Mo.
4. Champion Products Inc., 1979. Champion Products Inc., Eden Prarie, Minn.
5. Feed Production School. 1961. Feed production handbook. Feed Production School Inc., Kansas city Mo.
6. Koppers Co. Ine. 1977. Bulletin 4030, 5010, 5020, 5040, 5050, 5061, 5080. Koppers Co. Inc., Muncy, Pa.
7. Leaver, Richard H. 1980. The pelleting process. Koppers Co. Inc. Sprout Waldron Div. Muncy Pa.
8. Mc Ellhiney, Robert R. 1981. Personal communication. K. S. U. Manhattan, Ks.
9. Mc Ellhiney, Robert. R. 1980. " Is pelleting is profitable ?", Unpublished article. K. S. U. Manhattan Ks.
10. Park, K. K., and D. S. chung. 1982. Modeling and computer Programming of feed mill. ASAE Paper No. 82-3020. ASAE St. Joseph. Mi.
11. Park, K. K. 1982. Modeling and optimization of feed mill. Ph. D. Thesis. Kansas State University. Manhattan, K. S. 66506.
12. Park, K. K. and D. S. Chung, 1982. User's guide of computer programming for feed mill design. AID/DSAN-CA-0256 Imporovement of post harvest system. Food and Feed Insitute Kansas state University. Manhattan. K. S. 66506.
13. Parker, James R. 1981. Personal communication. California Pellet Mill Co. S.F. Ca.
14. Salisbury, Harry. 1981. Personal communication. M-E-C Co., Meodesha, Ks.
15. Schnaje, L. D. 1979. Grain dust pelleting cost and capital requirements for stationary and portable plants. USDA ESDA ESCS-71. Washington D. C.
16. Schultz, Roger. 1981. Personal communication. D and R construction company, Manhattan, Ks.
17. USDC. 1981. Industrial commodities prices index. Statistical abstract of the U. S. A. USDC. Washington, D. C .
18. USDC. 1981. Price index of commercial and factorial building construction review. USDC. Washington, D. C .
19. USDC. 1979. Index of selected agricultural trends, Pocket data handbook USA 79. USDC, Washington, D. C.
20. Vosloh, Jr. Carl J. 1968. Cost and economics of scale in feed manufacturing. Economics research series. Marketing research report. No. 815. USDA. Washington, D. C.
21. Vosloh, Jr. Carl J. 1776. Feed manufacturing cost and capital requirements. Economic research services. Agricultural economic report. No. 355.USDA. Washington D. C.