Using Linear Mathematical Programming Model to Reduce Feed Cost of Broiler Farms

استخدام نموذج البرمجة الخطية الرياضية لتقليل تكلفة العلف في مزارع الفروج

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Abstract:

This research aims at shedding light on the effectiveness of using linear mathematical programming models in the production management of Broiler farms, and proposing the optimal low-cost Broiler feed mix within the constraints of the available feed resources. The research also aims at studying the effect of the low cost of the mixt on the proposed financial evaluation indicators. Primary data were collected through a random sample of broiler chicken farmers to obtain data related to the production costs, revenues and technical operations during the production season of 2018 in the governorate of Swaida, Syria. The results showed that the total cost of one ton of the proposed starting batch, obtained by using the linear programming model, was 196,953.93 SYP/ton, meaning the cost decreased by 16.2%. While the total cost of one ton of the final mix proposed for the linear programming model amounted to 191324.8 SYP/ton, the cost decreased by 16.8%. Through analyzing the impact of feed costs' decline by 16% on the financial assessment indicators of the sample, it can be noted that the variable expenses decreased to 7,205,866 SYP/farm in the summer production cycle and to 8,150,358.4 SYP/farm in the winter production cycle. The value of the net income index and the gross margin increased to 9,214,777.9 SYP/farm and 1,206,278.04 SYP/farm respectively for the mix obtained by the programming model. The revenue to costs ratio increased to 1.123%, and the operating ratio decreased to 0.89%. Moreover, it was noted that the profitability of the invested SYP increased to 12.3%, and the time of the variable assets turnover decreased to 312.66 days.

Keywords: Linear Mathematical Programming, Optimal Diet, Broiler Chicken, Economic Indicators, Production Costs.

ملخص:

يهدف البحث إلى إلقاء الضوء على فعالية استخدام نماذج البرمجة الرياضية الخطية في إدارة الإنتاج لمداجن الفروج، واقتراح أفضل تركيبة علفية للفروج تخفض التكاليف، ضمن قيود الموارد العلفية المتاحة، ودراسة تأثير انخفاض تكلفة الخلطة المقترحة في مؤشرات التقييم المالي المدروسة، وقد جرى الاعتماد على بيانات أولية، من خلال عينة عشوائية من مربي فروج اللحم للحصول على بيانات متعلقة بتكاليف الإنتاج والإيرادات والعمليات الفنية للموسم الإنتاجي 2018 في محافظة السويداء السورية، وبينت النتائج أن: إجمالي تكلفة الطن من الخلطة البادئة المقترحة بتطبيق نموذج البرمجة الخطيّة بلغ 196953.93 ل.س للطن، أي انخفضت التكلفة بنسبة 16.2%. في حين أن إجمالي تكلفة الطن من الخلطة الناهية المقترحة لنموذج البرمجة الخطيّة بلغ 191324.8 ل.س للطن، أي انخفضت بنسبة 16.8%، وبدراسة أثر انخفاض تكلفة العلف 16% في مؤشرات التقييم المالي المحسوبة للعينة، ويلاحظ أن قيمة التكاليف المتغيرة انخفضت إلى 7205866 ل.س للمدجنة في الدورة الصيفية، وإلى 8150358.4 ل.س للمدجنة في الدورة الشتوية. وقيمة كل من مؤشر صافي الدخل والهامش الإجمالي ازدادت إلى 921477.9 و 1206278.04 ل.س/للمدجنة للخلطة المستخرجة بنموذج البرمجة، وارتفاع قيمة نسبة الإيرادات للتكاليف إلى 1.123%، ونسبة التشغيل التي انخفضت إلى 0.89%، في حين أن أربحية الليرة المستثمرة ارتفعت إلى 12.3%، وزمن دوران الأصول المتغيرة قد انخفض إلى 312.66 يوم.

الكلمات المفتاحية: البرمجة الخطية الرياضية، عليقة مثلى، الفروج، مؤشرات اقتصادية، تكاليف إنتاج.

Introduction

Broiler farming is considered an economic advantage, placing the poultry sector within the top industries as it increases the amount of protein in the person's diet, contributes in (gross national income) GNI, does not require massive space for its production, has high manufacturing efficacy, and has quick turnover of the invested capital and short lifespan (45-55 days) (Al-Jojo, 2006). It is important for countries like Syria, which is characterized by increased population growth, limited natural resources and a challenging climate, to optimize the use of the available resources and foster the concept of sustainability to have constant economic growth. This requires the implementation of policies that are based on resources productivity assessment in the sector of agriculture, in order to reach the maximum level of resources' economic revenues, while maintaining the resources' productivity. Thus, production policies in Syria should seek to establish the highest possible level of resources' productivity in the most efficient and economic manner (National Agricultural Policy Center, 2002). Farm planning seeks to distribute economic resources in a way that guarantees the optimal use of these resources in accordance with the present capabilities and conditions. Thus, linear programming is considered one of the most important planning methods to find the optimal approach for utilizing resources for a project (Al-Ashari, 2011).

Research Importance and Justification

Broiler farming is considered an agricultural activity that is influenced by various factors and uncontrolled external variables such as, climate change, environmental fluctuations, diseases, price fluctuations of production inputs and extent of openness to global markets. Consequently, chicken farmers have multiple production targets that are subject to a number of constraints related to the availability of economic resources. Thus, the importance of research stems from the necessity to implement effective scientific methods that help reduce the cost of feed of broiler farms and achieve possible maximum profit.

Purpose of the Research

The research aims at shedding light on the efficiency of utilizing linear mathematical programming for reducing the cost of feed of broiler farms. ***This purpose is achieved through:***

1. Analyzing the most important financial evaluation indicators for broiler farming projects in Swaida governorate.

2. Proposing the optimal feed mix that decreases costs, taking into consideration the constraints of the available feed resources.

3. Analyzing the impact of the proposed feed mix on financial evaluation indicators.

Previous Studies

A number of studies tackled the topic of financial evaluation of poultry farming projects.

Balao, Abdul Hussein, and Abed (2018) revealed that producers in al-Muthanna governorate in Iraq were incompetent in using production inputs, especially pharmaceutical drugs. However, it was noted that their net cash flow, net farm income and farm work revenues amounted to 30461.82 IQD; 2877825 IQD; 28023.04 IQD respectively. Return of capital was found to be 1.057 and payback period was found to be 0.88 year. These are considered good indicators for the projects.

Darwish and Younes (2016) explored how the crisis in Syria affected broiler farming and production through comparing prices and costs before and after the crisis. Results showed that productive efficiency of broiler farming in Latakia was 1.85 in 2010 and 1.20 in 2014. Economic efficiency was found to be 1.72 in 2010 and 1.09 in 2014. Payback period was found to be 1.3 year in 2010 and 9.8 years in 2014.

Jado (2013) revealed that the most important production inputs that impact Broiler production in Egypt are the number of chicks, amount of feed, number of hours of human labor, and number of dead chicks. These variables were proved to be significant. The average net revenues for the sample was found to be 2,178.43 EGP/ton. Al-Aboudi's (2014) study used the linear programming method to identify the optimal feed. The price of one ton of the feed obtained by the mathematical programming was 116,861 IQD less than the low-quality standard feed sold at the local market.

Nath and Ashok (2014), showed the optimal solution of the linear programming model provides feed mix lower in costs than the current feed. The researchers developed a feed mix composed of 22.98 kg of rice bran, 3.96 kg of wheat bran, 15.32 kg of fish meat, and 57.72 kg of sesame seeds. All of these ingredients constituted 100 kg of feed which contained the minimum requirements of macronutrients. The 100 kg cost was estimated to be 1,426.57 INR.

Al-Masad, al-Tahat, and al-Sharafat (2011), using linear programming model, revealed different feed mixes used in the diet of egg laying chicken in Jordan in addition to the present market prices and ingredients. It was noted that the cost of one portion of feed in all stages was 25-45 JD less per ton than the standard feed mix sold at the market.

Al-Deseit (2009), showed that the optimal feed mix, obtained by linear programming model, which costs the minimum, was composed of 68% corn, 25.07% soy beans, 4% wheat bran, 0.5% fish powder, 0.5% calcium diphosphate, 0.1% lysine, 0.32% methionine, 0.3% limestone, and 0.3% salt, in addition to soybean oil, vitamins and minerals.

Methodology

1. Data: The study relied on preliminary data through field visits to breeders and the official institutions responsible for this sector to collect data on production costs and current agricultural prices. The data was collected through a questionnaire that addressed costs, productions and technical issues for the production season of 2018 in Swaida, Syria.

2. Sample selection: The sample included 104 broiler farmers in Swaida, Syria. The sample size was calculated according to the following equation (Glenn, 1992; Yamane, 1967):

$$n = \frac{N}{1 + N(e)^2}$$

Where:

N: Size of the study population, 210 broiler farms (Central Agr Extension, 2016).

e: Precision level, ±7%.

n: Sample size

3. Statistical analysis software: IBM SPSS Statistics 23 and Excel Solver were used to process and analyze the data in order to solve optimization problems in mathematical programming.

4. Statistical analysis method: The study adopted a number of methods of descriptive statistics such as arithmetic mean and graphs, in addition to the following:

♦ Financial analysis: Through using a number of evaluation indicators (Atieh, 2008; Al-Thenyian &Sultan, 1993; Al-Atwan &al-Homsi, 2011), as follows:

- Net income= gross revenues- gross expenses
- Operating ratio= gross operating expense/net sales
- Profitability of invested SYP: (average of net annual income/project’s average expenses) * 100%
- Net Profit margin= Gross Product – variable expenses
- Revenues to expenses ratio
- The break-even point= fixed costs/(total sales revenues-variable expenses) * 100
- Variable assets turnover rate= gross domestic production/value of variable expenses
- Turnover time of variable assets= 365/ variable assets turnover

♦ Quantitative Analysis for Management: Using one of the Operations Research methods, which is linear programming. It is categorized under Decision Science, which has different common models. It is used to show the optimal use of production activities in light of the available resources and potentials. In other words, it is used for solving problems through finding optimal combinations of activities in order to achieve one of the following targets: maximization or minimization (Benjamin, 1985; Beneke, 1982&; Hazell & Norton, 1986). Linear programming is expressed as follows (maximization or minimization):

$$(\text{maximization})\text{or }(\text{minimization})\ z = \sum_{j=1}^{n} c_j\, x_j$$

Subject to:

$$\sum_{j=1}^{n} a_{ij}\, x_j \ \geq\leq\ b_i \quad \text{for} \quad i = 1,2,\ldots\ldots,m$$

$$x_j \ \geq 0 \qquad \text{for} \quad j = 1,2,\ldots\ldots,n$$

Z:	Objective function	bi:	Available resources
C:	Coefficients of the objective function	n:	Number of activities
aij:	Coefficient Constraints	m:	Number of constraints
Xj	Activities (nominal variables)	Xj ≥ 0:	Non-negativity condition

Results and Discussion:

First: Economic Evaluation of broiler Farming Projects in Swaida:

1.1 Calculating total expenses:

The analysis of the questionnaire that was distributed to the sample of the study revealed that the expenses of producing 1kg of chicken meat is calculated, and the average expenses of five annual production cycles (2 summer cycles and 3 winter cycles) is calculated, noting that the average production cycle, starting from chicks rearing till marketing, lasts 45 days. The sum of fixed annual expenses were found to be 1,413,046.37 SYP for an average-sized farm, 720 m², that has an average number of chickens of 6478 chickens in summer cycle and 6541 chickens in winter cycle. Labor costs account for 74.15% of the fixed annual expenses, followed by the farm's rent of 23.30%. The fixed annual expenses for one production cycle amounted to 282,609.27 SYP per farm as detailed inTable1.

Table 1:

Average of fixed annual expenses for broiler farms according to the sample of the study

Item	Value SYP	Percentage %
1.Annual Labor Costs	1,047,805.98	74.15
2.Rent	329,230.77	23.3
3.License Fees	29,600.96	2.09
4.Income Tax (Finance)	1,403.85	0.1
5.Service Fees (Municipality)	639.42	0.05
6.Fees of Union's Supervision	1,403.85	0.1
7.Buildings and Land Tax	2,961.54	0.21
Total Fixed Annual Expenses	1,413,046.37	100
Total Fixed Annual Expenses per Production Cycle per Farm	282,609.27	

Source: Analysis of the questionnaire

Meanwhile, the average variable expenses for the summer production cycle amounted to 8,093,997.49 SYP per farm, and the average variable expenses for the winter production cycle amounted to 9,052,893 SYP per farm as detailed in Table 2.

Table 2:

The average variable expenses for the production cycle of broiler farms according to the sample of the study

Item	Summer Production Cycle		Winter Production Cycle	
	Value SYP	Percentage %	Value SYP	Percentage %
Chicks	1,524,139.42	18.83	1,656,163	18.29
Bedding	173,050.48	2.14	227,096.2	2.51
Water	94,721.15	1.17	100,701	1.11
Coal	226,130.77	2.79	820,873.1	9.07
Electricity	119,305.29	1.47	172,430.3	1.9
drugs and Vaccine	386,464.42	4.77	415,422.1	4.59
Feed	5,550,820.57	68.58	5,640,842	62.31
Cleaning and Disinfecting Substances	19,365.38	0.24	19,365.38	0.21
Total	8,093,997.49	100	9,052,893	100

Source: Analysis of the questionnaire

Table 3 shows the details of both variable and fixed total expenses. The analysis of the table reveals that variable expenses account for 97% of gross expenses in both summer and winter cycles. The total expenses for one chicken were found to be 1,441.87 SYP in summer, 1,568.79 SYP in winter, while the cost of producing 1kg of chicken meat was found to be 776.11 SYP in summer, and 782.57 SYP in winter.

Table 3:

Gross expenses for both summer and winter production cycles

Expenses	Summer Production Cycle		Winter Production Cycle	
	Value SYP	Percentage %	Value SYP	Percentage %
Variable Expenses SYP/Farm	8,093,997.49	96.63	9,052,893.16	96.95
Fixed Expenses SYP/Farm	282,609.27	3.37	282,609.27	3.03
Gross Expenses SYP/Farm	8,376,606.76	100	9,335,502.44	100
Number of Chicks	6,478		6,541	
number of deaths	668		590	
*Actual number of chicks	5,810		5,951	
Cost of One Chicken	1,441.87		1,568.79	
Amount of Meat in Ton	10.79		11.93	
Amount of Meat in Kg	10,793.08		11,929.33	
Cost of Producing 1 Kg of Meat	776.11		782.57	

Source: Analysis of the questionnaire

*: Actual number of chicks = total number of chicks - number of deaths

1.2 relative importance of variable expenses items:

The analysis of both summer and winter cycles' items, shows that feed expenses came first in terms of relative importance of broiler farms' variable production expenses in the governorate of Swaida, accounting for 62% of gross variable expenses in summer cycle and 69% in winter cycle. Meanwhile, expenses for purchase of chicks account for 18.19% of the gross variable expenses, while healthcare costs, such as vaccine and drugs, account for 5% of gross variable expenses in both summer and winter cycles. The costs of coal, which is used in heating, constitute 9% of the gross variable expenses in winter and only 3% of the gross variable expenses in summer.

1.3 Revenues and financial evaluation indicators:

Revenues included both main revenue from meat production and secondary revenue from by-products (poultry litters). Table 4 shows that the total revenue in the production cycle generated from the main product, meat, amounted to 8,361,202 SYP per farm. The main product's materiality constituted 99% of the gross revenues, while the total revenues from the sale of remnants amounted to 50,942.3 SYP per farm according to the study sample. Moreover, it was found within the sample that broiler farms' projects in the governorate of Swaida did not show a real economic feasibility according to all of the economic indicators as demonstrated by the following marginal values. First, the positive value of both the net income indicator, 35,537.47 SYP per farm, and the gross margin, 318,146.7 SYP per farm per production cycle. Second, the ratio of revenues to costs was found to be 1.004%, where the higher the ratio is than 1%, the more successful the project is. Third, operating ratio was found to be 0.996%, where the lower the ratio is than 1%,the more economically acceptable the project is. Last, the profitability of the invested

SY Preached 0.42% as shown in Table 4.

The financial evaluation indicators showed that these projects were not feasible for winter operating cycles and appeared with particularly negative values: net income, gross margin, and revenue on sales ratio. This is due to the fact that the projects afford, in addition to all their operating costs, an increase in the heating costs due to the high fuel prices, the high prices of chicks, in addition to the high consumption of medicines and vaccines in the winter cycles, as a result of the chances of the spread of pandemic diseases, all with relative stability at the sale prices of broilers. Referring to Table 2, and by comparing the details of the costs of the production process inputs, the difference between the variable costs for the summer and winter operating cycles is clear.

Table 4.

Revenues and the financial assessment indicators on the examined sample

Indicators	Summer Production Cycle	Winter Production Cycle
Total revenue from meat	8,361,202	7,606,063
Total revenue from poultry litters	50,942.3	102,653.9
Sum	8,412,144	7,708,716
Net income (net revenues of the farm)	35,537.47	-1,626,786
Operation rate	0.996	1.21
The profitability of invested Syrian Pound (Lira)	0.42	-17.4
Gross margin	318,146.7	-1,344,177
Revenues rate to costs	1.004	0.83
Break point	0.89	-0.21
The average of variable asset turnover	1.039	0.85
The timeframe of variable asset	351.2	428.65
Return on sales ratio	0.42	-21.1

Source: Analysis of the questionnaire

Second: The Mathematical Formula of the Linear Programming Model of the Optimal Feed Mix

This section deals with the study and analysis of the mathematical linear programming model of the optimal feed mix in the event of introducing any available feed component. This is accomplished through the study of the Starting ration, then the study of the Final ration, provided that the proposed feed mixes achieve the minimum and maximum limits of the required food components. (see annexes 1 & 2). The nutrition model will be adopted following two periods where the difference will be noticed in the amount of protein and energy that are needed to be available in the feed mix. The starting feed aged from one day- 4 weeks and had the energy of 3200 k cal ME/ kg of feed and 23% protein, while the final feed aged from 4 weeks was used for marketing, with 3200 k cal ME/ kg feed energy and 19% protein (Al-Rabee'i, 2013).

2.1. The linear mathematical analysis of the feed mix:

The linear mathematical programming model used to produce the optimal broiler chicken consists of;

A. Objective function: to minimize the cost of the bush feed mix to the minimum level, as follows;

$$\min z = 165x1 + 125x2 + 127x3 + 250x4 + 70x5 + 200x6 + 280x7 + 285x8 + 200x9 + 500x10 + 300x11 + 350x12 + 300x13 + 250x14 + 550x15 + 233.2x16 + 792x17 + 1496x18 + 50x19 + 1980x20$$

B. Constraints: These are the nutrition values that should be available in the bush.

	Constraints	Constraints Equations
1	All ingredients	$X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + X9 + X10 + X11 + X12 + X13 + X14 + X15 + X16 + X17 + 1X18 + X19 + X20 = 1000$
2	Barley maximum level	$X2 \leq 250$
3	Bran maximum level	$X5 \leq 100$
4	Grains maximum level	$X1 + X2 + X3 + X4 + X5 \leq 500$
5	legumes maximum level	$X13 + X14 \leq 100$
6	Corn oil maximum level	$X15 \leq 30$

	Constraints	Constraints Equations
7	Salt maximum level	$X19 \le 3.5$
8	Salt & vitamins maximum level	$X20 \le 3$
9	Fats maximum level	$2.5X1 + 1.8X2 + 3.8X3 + 2.9X4 + 3X5 + 2.5X6 + 0.8X7 + X8 + 2.9X9 + 2.8X10 + 10X11 + 10X12 + 95X15 \le 7000$
10	Humidity maximum level	$11X1 + 11X2 + 12X3 + 11X4 + 11X5 + 9X6 + 10.4x7 + 10x8 + 7x9 + 10x10 + 8x11 + 5x12 \le 10000$
11	Fibers maximum level	$3X1 + 5.5X2 + 2.2X3 + 2X4 + 11X5 + 1.3X6 + 7X7 + 3.9X8 + 5X9 + 14X10 + X11 + 2X12 \le 7000$
12	Ash maximum level	$1.6X1 + 2.4X2 + 1.8X3 + 1.7X4 + 6.1X5 + 2X6 + 5.7X7 + 5.6X8 + 9.3X9 + 7.1X10 + 21.7X11 + 71.8X12 \le 5000$
13	Phosphorus maximum level	$0.31X1 + 0.36X2 + 0.28X3 + 0.13X4 + 1.15X5 + 0.19X6 + 0.65X7 + 0.62X8 + 0.16X9 + 0.42X10 + 2.95X11 + 14X12 + 0.18X13 + 0.11X14 + 18.7X16 \le 1000$
14	Calcium maximum level	$0.05X1 + 0.03X2 + 0.02X3 + 0.04X4 + 0.14X5 + 0.29X7 + 0.27X8 + 0.38X9 + 2.02X10 + 5.02X11 + 30X12 + 0.2X13 + 0.52X14 + 22X16 \le 1500$
15	Sodium maximum level	$0.07X1 + 0.02X2 + 0.01X3 + 0.01X4 + 0.3X5 + 0.03X6 + 0.24X7 + 0.34X8 + 0.3X10 + 0.46X12 \le 250$
17	Lysine maximum level	$0.39X1 + 0.4X2 + 0.26X3 + 0.25X4 + 0.61X5 + 1.29X6 + 2.69X7 + 2.69X8 + 1.73X9 + 1.09X10 + 4.83X11 + 0.87X12 + 1.34X13 + 1.73X14 + 100X17 \le 1400$
18	Methionine maximum level	$0.26X1 + 0.18X2 + 0.18X3 + 0.35X4 + 0.23X5 + 2.79X6 + 0.62X7 + 0.67X8 + 2.22X9 + 1.86X10 + 2.32X11 + 0.29X12 + 0.59X13 + 0.41X14 + 100X18 \le 600$
19	Di calcium phosphate maximum level	$X16 \le 20$
20	Corn oil minimum level	$X15 \ge 20$
21	Legumes minimum level	$X13 + X14 \ge 30$
22	Salt minimum level	$X19 \ge 2.5$
23	Vitamins & salt minimum level	$X20 \le 3 \ge 2.5$
24	Fats minimum level	$2.5X1 + 1.8X2 + 3.8X3 + 2.9X4 + 3X5 + 2.5X6 + 0.8X7 + X8 + 2.9X9 + 2.8X10 + 10X11 + 10X12 + 95X15 \ge 4000$
25	Humidity minimum level	$11X1 + 11X2 + 12X3 + 11X4 + 11X5 + 9X6 + 10.4x7 + 10x8 + 7x9 + 10x10 + 8x11 + 5x12 \ge 5000$
26	Fibers minimum level	$3X1 + 5.5X2 + 2.2X3 + 2X4 + 11X5 + 1.3X6 + 7X7 + 3.9X8 + 5X9 + 14X10 + X11 + 2X12 \ge 3000$
27	Ash minimum level	$1.6X1 + 2.4X2 + 1.8X3 + 1.7X4 + 6.1X5 + 2X6 + 5.7X7 + 5.6X8 + 9.3X9 + 7.1X10 + 21.7X11 + 71.8X12 \ge 2000$
28	Phosphorus minimum level	$0.31X1 + 0.36X2 + 0.28X3 + 0.13X4 + 1.15X5 + 0.19X6 + 0.65X7 + 0.62X8 + 0.16X9 + 0.42X10 + 2.95X11 + 14X12 + 0.18X13 + 0.11X14 + 18.7X16 \ge 500$
29	Sodium minimum level	$0.07X1 + 0.02X2 + 0.01X3 + 0.01X4 + 0.3X5 + 0.03X6 + 0.24X7 + 0.34X8 + 0.3X10 + 0.46X12 \ge 100$
30	Lysine minimum level	$0.39X1 + 0.4X2 + 0.26X3 + 0.25X4 + 0.61X5 + 1.29X6 + 2.69X7 + 2.69X8 + 1.73X9 + 1.09X10 + 4.83X11 + 0.87X12 + 1.34X13 + 1.73X14 + 100X17 \ge 800$
31	Methionine minimum level	$0.26X1 + 0.18X2 + 0.18X3 + 0.35X4 + 0.23X5 + 2.79X6 + 0.62X7 + 0.67X8 + 2.22X9 + 1.86X10 + 2.32X11 + 0.29X12 + 0.59X13 + 0.41X14 + 100X18 \ge 300$
32	Dicalcium phosphate minimum level	$X16 \ge 10$
33	Non negative entry	$X1, X2, X3, X4, X5, X6, X7, X8, X9, X10, X11, X12, X13, X14, X15, X16, X17, X18, X19, X20 \ge 0$

However, the starting and final mix differ from each other in the value of protein and energy, thus the constraint identified between the two bush feed mix is the ratio of energy to protein and so the constraint entryis as follows:

Starting	minimum	$271.3043X1 + 240X2 + 418.75X3 + 281.58X4 + 82.80X5 + 62.66X6 + 50.6818X7 + 50.309X8 + 41.79X9 + 54.29X10 + 45.8X11 + 115.53X12 + 132.5X13 + 112.6383X14 \ge 139000$
	maximum	$271.3043X1 + 240X2 + 418.75X3 + 281.58X4 + 82.80X5 + 62.66X6 + 50.6818X7 + 50.309X8 + 41.79X9 + 54.29X10 + 45.8X11 + 115.53X12 + 132.5X13 + 112.6383X14 \le 139130$
Final	minimum	$271.3043X1 + 240X2 + 418.75X3 + 281.58X4 + 82.80X5 + 62.66X6 + 50.6818X7 + 50.309X8 + 41.79X9 + 54.29X10 + 45.8X11 + 115.53X12 + 132.5X13 + 112.6383X14 \ge 168000$
	maximum	$271.3043X1 + 240X2 + 418.75X3 + 281.58X4 + 82.80X5 + 62.66X6 + 50.6818X7 + 50.309X8 + 41.79X9 + 54.29X10 + 45.8X11 + 115.53X12 + 132.5X13 + 112.6383X14 \le 168421$

2.2. Application of linear programming model:

The percentage of the main ingredients of the optimal mix. Table 5 shows the quantities of the main ingredients of the proposed feed mix, and the proportion of each in the optimal mix with the cost, as follows;

- The starter: the amount of barley was the highest with respect to the ingredients of the mix as it reached 250kg, 25% of the mix, followed by sunflower meal which amounted to 145.61kg, around 14.56 % of the mix, then soybean meal which amounted to 140.8 kg, around 14.08% of the mix. As for wheat, corn, bran, lentil, soybean meal and corn oil, all amounted to 48%. The quantities of each in the mix were as follows respectively; 133.3, 16.6, 100, 100, 63.8 and 23.7 kg at about 13.3%, 1.66%, 10%, 10%, 6.38% and 2.37%. For feed supplements (dicalcium, food salt, as well as vitamins and mineral salts), they were in the order of 20, 3.5 and 2.5 kg at 2%, 0.35% and 0.25% respectively.
- The finisher: The amount of yellow corn amounted to 203.282 kg around 20.33% which is the highest value in the mix, then barley at 196.71 kg with 19.67% of the mix, then sunflower meal and soybean meal 48% which amounted to 148 kg of the mix each reached 14.8%. As for bran, lentil, soybean meal and corn oil, they amounted to 44%, as follows 100, 100, 56.95, 20.5 kg(10%, 10%, 5.65% and 2.05% respectively). As for the supplementary feed (dicalcium, food salt, vitamins and mineral salts), they were in the order of 20, 3.5, 2.5 with 2%, 0.35%, 0.25% respectively.

Table 5.

Results of using linear mathematical programming model in the proposed feed mix.

Ingredients	*Price SYP	Amount		Amount in percent		Cost	
		Final	Starting	Final	Starting	Final	Starting
Wheat	165	0	133.34	0	13.33	0	22,000.95
Barley	125	196.72	250.00	19.67	25.00	24,589.78	31,250
Corn	127	203.28	16.66	20.33	1.67	25,816.78	2,115.94
Sorghum	250	0	0	0	0	0	0
Coarse bran	70	100	100	10	10	7,000	7,000
Corn gluten 60%	200	0	0	0	0	0	0
Soybean meal 44%	280	56.95	140.84	5.70	14.08	15,946.82	39,434.92
Soybean meal 48%	285	148.13	63.82	14.81	6.38	42,216.98	18,188.27
Sunflower meal	200	148.40	145.61	14.84	14.56	29,679.48	29,122.01
Sesame meal	500	0	0	0	0	0	0
Fish meal	300	0	0	0	0	0	0
Bone meal	350	0	0	0	0	0	0
Chickpeas	300	0	0	0	0	0	0
Lentil	250	100	100	10	10	25,000	25,000
Corn oil	550	20.52	23.73	2.05	2.37	11,285.95	13,052.84
Dicalcium phosphate	233.20	20	20	2	2	4,664	4,664
Lysine	792	0	0	0	0	0	0
Methionine	1496	0	0	0	0	0	0
Salt	50	3.50	3.50	0.35	0.35	175	175
Vitamins and salt	1980	2.50	2.50	0.25	0.25	4950	4950
Total		1000	1000	100	100	191,324.80	196,953.93

Reference: These calculations were obtained using excel solver.

3.2. The cost of the optimal feed mix:

Tables 5 & 6 show the cost of one ton of feed according to the results of the applied model and it was compared with breeders' cost of one ton of feed. The gross cost of one ton of the proposed starting feed mix when applying the linear programming model was about 196,953.93 SYP per ton. While the average price per ton for the starter feed mix used by the breeders was about 235,000 SYP. There is a decrease in cost about 38,046.066 SYP per ton, i.e. the cost decreased by about 16.1988%.

In the other hand, the gross cost per ton of the proposed final mix through the application of the linear programming model is about 191,324.8 SYP per ton, while the average price per ton for the final feed mix used by the breeders was about 230,000 SYP, i.e. there is a decrease in cost about 38,675.2 per ton, as the cost decreased by about 16.8%.

Table 6:

The cost per ton of the mix obtained from the linear programming model and the mix used by the breeders

The Feed Mix Cost	Starting	Final
Used by the breeders SYP/ton	235,000	230,000
The mix obtained by using the linear programming model	196,953.934	191,324.8
The difference between the two mix	38,046.066	38,675.2
The difference in percent	16.1898	16.8

Source: These results were calculated based on the previous table, from the questionnaire

Third: The Impact of Feed Cost Decreased by 16% on the Indicators of the Financial Evaluation

The results of the study showed that the rearing projects of broilers chicken in the governorate of Sweida with respect to the sample did not show any actual economic feasibility in terms of all economic indicators (summer production cycle), as what the boundary values of their indicators have shown. On the other hand, indicators showed the infeasibility of these projects during the winter production cycle of the sample. The results of applying the linear programming model revealed that the total cost per ton of the starting feed was about 196,953,934 SYP, i.e. the cost per one ton decreased by approximately 16.1898%. The total cost per ton of the proposed final feed mix obtained by the application of the linear programming model amounted to about 191,324.8 SYP, thus reducing the cost per ton by about 16.8%. However, in this section, we will tackle the impact of feed cost decrease by 16% (mean) on the computerized financial evaluation indicators of the sample, through studying the impact of feed cost decrease on the variable costs and the stability of the fixed computerized variables of the sample, in addition to the macro fixed revenues (from meat and remnants).

3.1.The impact of feed cost decrease by 16% on the indicators of the financial evaluation on the variable costs:

Table 7 shows that during the summer production cycle when comparing the ratio of the feed cost vis-à-vie the variable costs, it was found that it decreased from 68.58% to 64.71%, and from 62.31% to 58.14% during the winter production cycle. However. The cost of rearing chicks increased from 18.83% to 21.15% from the variable costs during the summer production cycle, and from 18.29% to 23.32% during the winter production cycle. Moreover, the cost of the variable costs has decreased from 8,093,997.5 SYP of the chicken farm during the summer production cycle to 7,205,866 SYP, and the cost also decreased from 9,052,893.1 SYP to 8,150,358.4 of the chicken farm during winter production cycle.

Table 7.

Variable costs for both summer and winter production cycle, after the cost of the obtained feed mix by using the linear program has decreased by 16%

The Cost of the Farm During the Cycle in SYP	The obtained feed mix by using the linear program			
	Summer Cycle		Winter Cycle	
	Value	%	Value	%
1. Chicks	1,524,139	21.15	1,656,163	20.32

The Cost of the Farm During the Cycle in SYP	The obtained feed mix by using the linear program			
	Summer Cycle		Winter Cycle	
	Value	%	Value	%
2. Bedding	173,050.5	2.4	227,096.2	2.79
3. Water	94,721.15	1.31	100,701	1.24
4. Coal	226,130.8	3.14	820,873.1	10.07
5. Electricity	119,305.3	1.66	172,430.3	2.12
6. Drugs and vaccines	386,464.4	5.36	415,422.1	5.1
7. Feed	4,662,689	64.71	4,738,307.3	58.14
8. Sterilizing and cleaning materials	19,365.38	0.27	19,365.38	0.24
The total of variable costs	7,205,866	100	8,150,358.4	100

Source: Computed based on the questionnaire data and the results of the proposed linear programming model.

3.2.The impact of feed cost decrease by 16% on the indicators of financial evaluation:

By analyzing table 8, we notice that the indicators of the financial evaluation with respect to the sample has improved. The positive value for each net income index is 35,537.47 SYP/farm; while the gross margin is 318,146.7 SYP/farm per one production cycle of the normal feed mix which has increased to 921,477.99 while the gross margin amounted to 1,206,278.42 SYP/farm to the mix obtained by using the linear programming model. However, the value of the revenues ratio to costs has increased to more than 1% from 1.004% to 1.123% and this shows that the project is more profitable when it jumps above 1%. Moreover, the operation ratio has decreased from 0.996% to 0.890% and this indicates that the project is feasible. Nevertheless, the profitability of the invested pound rose from 0.42% to 12.302%. Moreover, the ratio of return on sales increased from 0.42% to 10.954%, and the turnover of variable assets decreased from 351.2 to 312.66 days as shown in table 8.

Although the financial indicators in winter cycles when using mixes extracted by mathematical linear programming models were better, there were clear losses as the financial indicators did not show the economic feasibility of these projects. This is due to several main factors imposed by the production process during the winter cycles, ***the most important of which are:***

- High heating costs (hydrocarbons or coal).
- High mortality rates due to prevailing weather factors.
- High prices of chickens during winter cycles.

Table 8.

Impact of the feed cost decrease by 16% on the computerized indicators of the financial evaluation of the sample.

Indicator	Summer Cycle		Winter Cycle	
	Normal mix	Linear programming mix	Normal mix	Linear programming mix
Net income (of the farm)	35,537.47	921,477.99	-1,626,786	-726,442.056
2. Operation ratio	0.996	0.890	1.21	1.094
3. The profitability of the invested Lira	0.42	12.302	-17.4	-8.612
4. Gross margin	318,146.7	1,206,278.04	-1,344,177	-441,642.014
5. The ratio of revenues to costs	1.004	1.123	0.83	0.914
6. Break point	0.89	0.236	-0.21	-0.645
7. The average of variable assets	1.039	1.167	0.85	0.946
8. The cycle duration of the variable assets	351.2	312.66	428.65	385.911
9. Return on sales ratio	0.42	10.954	-21.1	-9.424

Source: Computed based on the questionnaire data and the results of the proposed linear programming mode

Conclusion

The results of applying the linear programming model showed the following:

1. For the starter: The amount of barley reached the highest value of the mix ingredient. It amounted to 250kg, i.e. 25% of the mix, then sunflower meal which reached 145.61 kg by about 14.56% of the mix, followed by soybean meal 44%, 140.8 kg, i.e. 14.08% of the mix. The total cost per ton of the proposed starting mix when applying the linear programming model amounted to about 196,953,934 SYP, i.e. the cost decreased by approximately 16.1988%.

2. For the finisher: The amount of yellow corn reached the highest value of the mix ingredients. It amounted to 203.282 kg, i.e. 20.3% of the mix, then barley which reached 196.71 kg, i.e. 19.67% of the mix, followed by sunflower meal and soybean meal which amounted to 48%, each for 148 kg, i.e. 14.8%. However, the total cost of one ton of the final feed that was obtained using the linear programming model amounted to 191,324.8 SYP, i.e. which decreased by 16.8% approximately.

3. Through analyzing and studying the impact of feed cost decrease by 16% on the computed financial indicators of the sample, it is noted that the value of the variable costs has decreased to 7,206,866 SYP/farm during the summer production cycle and to 8,150,358.4 SYP/farm during the winter production cycle.

4. The indicators of the financial evaluations has improved at the sample level, as the value of the gross and net margin has increased to 921,477.999 and 1,206,278.042 SYP/farm of the obtained mix by using the linear programming model. The ratio of revenues to costs jumped above 1% to reach 1.123 %, and the operation cost increased to 0.890% whereas the profitability of the invested Lira increased to 12.302%. The net profit margin increased to 10.954 % and the turnover of the variable assets decreased to 312.66 days.

5. The results obtained showed that they are consistent with what was presented in the research of studies that used the linear programming methodology to determine optimal feeds; The use of programming models in the selection of feed mixtures reduced the cost of feed and this is shown in Al-Aboudi (2014), Nath & Ashok (2014), Almasad et.al.(2011) and Al-Deseit (2009).

Recommendations

1. The possibility to apply the linear programming model in the poultry sector, in order to identify the optimal feed mix at the lowest cost. Provide a model of the mix which fits the price fluctuation and the provision of the feed ingredients at the lowest cost.

2. The availability of different feed ingredients that provide nutrients and the needed conditions in the composition of the feed mix, which can be replaced partially in different quantities and percentages, or can be replaced in full, in the event of high prices, or lack of availability of such materials.

3. The study recommends the application of the linear programming model in identifying the optimal and civil mix and its cost in the poultry sector, as well as to expand the introduction of other feed ingredients in the mix if available.

4. The need for applying the proposed mixture in reality, to review its nutritional suitability for broilers.

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Annexes

Annex 1:

The Chemical Analysis of the Feed Ingredients in the Proposed Mix

symbol	Ingredient	*Price SYP	Calories c	Protein %	Fats %	Fibers %	Ca %	P %	Na %	Lysine %	Methionine %
x1	Wheat	165	3120	11.5	2.5	3	0.05	0.31	0.07	0.39	0.26
x2	Barely	125	2640	11	1.8	5.5	0.03	0.36	0.02	0.4	0.18
x3	Yellow corn	127	3350	8	3.8	2.2	0.02	0.28	0.01	0.26	0.18
x4	White corn	250	3210	11.4	2.9	2	0.04	0.13	0.01	0.25	0.35
x5	Coarse bran	70	1300	15.7	3	11	0.14	1.15	0.3	0.61	0.23
x6	Yellow corn gluten 60%	200	3720	62	2.5	1.3	0	0.19	0.03	1.29	2.79
x7	soybean meal 44%	280	2230	44	0.8	7	0.29	0.65	0.24	2.69	0.62
x8	Soybean meal 48%	285	2440	48.5	1	3.9	0.27	0.62	0.34	2.69	0.67
x9	Sunflower meal	200	2320	45	2.9	5	0.38	0.16	0	1.73	2.22
x10	Sesame meal	500	2210	43.5	2.8	14	2.02	0.42	0.3	1.09	1.86

symbol	Ingredient	*Price SYP	Calories c	Protein %	Fats %	Fibers %	Ca %	P %	Na %	Lysine %	Methionine %
x11	Fish powder	300	3190	72.3	10	1	5.02	2.95	0	4.83	2.32
x12	Bones powder	350	2150	50.4	10	2	30	14	0.46	0.87	0.29
x13	Chickpeas	300	2756	20.8	-	-	0.2	0.18	0	1.34	0.59
x14	Lentil	250	2647	23.5	-	-	0.52	0.11	0	1.73	0.41
x15	Corn oil	550	8800	-	95	-	-	-	-	-	-
x16	deCalcium PhoSYPhate	233.2	-	-	-	-	22	18.7	-	-	-
x17	Lysine	792	-	-	-	-	-	-	-	100	-
x18	Methionine	1496	-	-	-	-	-	-	-	-	100
X19	Salt	50	-	-	-	-	-	-	-	-	-
x20	Vitamins and salt	1980	-	-	-	-	-	-	-	-	-

Source: Al-Aboudi (2014), NRC (1994), Al-Ribat & Hassan (1986) (*): prices for 2018.

Annex2:

Maximum and Minimum Limits of the Most Important Nutrition Elements

Ingredients	Maximum limit	Minimum limit
Fats	%7	%4
Humidity	%10	%5
Fibers	%7	%3
Ash	%5	%2
Phosphorus	%0.1	%0.5
Calcium	%1.5	%0.7
Sodium	%0.25	%0.1
Lysine	1.4	%0.8
Methionine	%0.6	%0.3
Phosphorus/ Calcium	%2	%1.5
Vegetable oils	%3	%2
legumes	%10	%0.03
Grains	%50	-
Salt Kg/Tons	3.5	2.5
Vitamins and Salts Kg/Tons	3	2.5
Di calcium phosphate Kg/ Tons	20	10
Barley	%25	-
Bran	%10	-

Source: Al-Kassar (2012), Al-Rabee›i(2013)