



**USING MICROSOFT EXCEL IN FORMULATING POULTRY  
RATIONS BY LINEAR PROGRAMMING**  
**Rafh Mohammed Taher Khulel**

Dep. of Anim. Prod fac. of Agric.e And Forestry Univ. of Mosul/Iraq

**Corresponding author:** Rafh Mohammed Email: rafhtaher2017@gmail.com

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**ABSTRACT:** Formulation of the least cost rations that provides the nutrient requirements of birds is an important goal in poultry production . The aim of the present study was to create an application in the Excel program for formulation of low-cost poultry diets that provide adequate nutritional requirements using linear programming based on the Solver function of the Excel program and composition of common feed ingredients used in poultry diets (yellow corn, wheat, soybean meal , barley, wheat bran, protein concentrate, limestone, table salt, di-calcium phosphate, vitamins and minerals premix ,and vegetable oil), if their default prices are 500, 450, 750, 350, 250,1750, 250, 100, 500, 4500,and 1500) Iraqi Dinar / kg, respectively. The results showed that the Solver function in - Excel can be used to solve linear programming models such as those used for formulation of least cost poultry rations. This Microsoft Excel application is ready to use and can be used to assist researchers and students in formulating poultry rations that provide the desired nutritional requirements of poultry at the lowest cost.

**Key words :** Application, Excel, Poultry, Ration

**INTRODUCTION**

Feed formulation is an important factor of nutritional science where nutritionists apply their knowledge to meet specified nutritional requirements by formulating more economical feeds for maximum performance ( Alhotan, 2016) .

Patil et al (2017) indicate that advances in technology have made possible the formulation of feed for a number of feed ingredients using linear programming. Afolayan and Afolayan(2008) have stated that diet formulation can be defined as the mixing of a several ingredients at certain quantities to provide the feed requirements of an animal in terms of different nutrients at a certain stage". Onwurah (2008) stated that additional factors should be taken in to consideration with regards to feed formulation such as the acceptability to birds, the digestibility of feed, the cost of feed ingredients, and the presence of anti-nutritional factors and toxin. Concalves et al (2015) developed a quadratic feed intake and weight gain equations, according to broiler sex and feeding phase, that could be applied in a nonlinear formulation model .

Radhika and Rao( 2010) indicated that least cost ration formulation using linear programming (LP) is an ideal approach for optimizing cost of feed.

Linear programming is a preferential approach for poultry feed formulation as the properties of feed ingredients are not expected to change as a consequence of mixing (Rahman and Sie, 2016) .

Oladokun and Johnson(2012) developed a mathematical model of the feed formulation problem using Thirteen decision variables and 14 constraints were identified, and the optimal solution of the linear programming model gave a 9% reduction in feed formulation costs compared with the existing method on the farm. Zhang and Roush(2002) have

applied a multiple objective programming model for feed formulation Using Excel solver to formulate broiler rations based on nine decision variables, 10 parameters, and a set of 12 obtained constraints. Olugbenga et al (2015) found that a feed formulation model generated by linear programming can provide approximately 7.48% and 9.96% reduction in feed costs compared with existing formula for broiler starter and finisher rations respectively. Pesti and Seila (1999) presented a simpler less expensive method based on Excel spreadsheets to solve linear and nonlinear (stochastic) feed formulation models. Similarly, Nolan( 2001) has suggested an Excel spreadsheet application (UNEFom) for least cost formulation of poultry and pigs feeds that are suitable for the purpose of teaching and use by small producers . Microsoft has introduced the Solver feature in the Excel spreadsheet program to solve linear programming problems which can be used to facilitate the formulation of less expensive diets that provide the desired nutritional requirements. On the basis of the Excel Solver feature, we conducted the present study with the aim of creating an Excel application that can be used to formulate poultry rations.

**MATERIALS AND METHODS**

The linear programming model is designed to find poultry diets of the target function, which is to reduce the cost of the diet to a minimum:

$$\text{Min cost} = \sum C_i X_i$$

Where  $C_i$  is the cost of ingredient  $i$

$X_i$  is the quantity of ingredient  $i$

Where  $I = 1, 2, 3, \dots, 11$

Under the constraints :

$$\sum (X_1 * 3340 + \dots + X_{11} * 9000) \geq O_6$$

$$\sum (X_1 * 3340 + \dots + X_{11} * 9000) \leq O_7$$

$$\sum (X_1 * 9.03 + \dots + X_{11} * 0) \geq O_8$$

$$\sum (X_1 * 9.03 + \dots + X_{11} * 0) \leq O_9$$

$$\sum (X_1 * 0.38 + \dots + X_{11} * 0) \geq O_{10}$$

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$$\begin{aligned} \sum(X1*0.2 + \dots + X11*0) &\geq O11 \\ \sum(X1*0.04 + \dots + X11*0) &\geq O12 \\ \sum(X1*0.08 + \dots + X11*0) &\geq O13 \\ \sum(X1*2.01 + \dots + X11*0) &\leq O14 \\ \sum(C1*4.34 + \dots + C11*99) &\leq O15 \\ 0.05 \geq G1 \leq 0.10 \\ I_1 &= 0.0025 \\ K_1 &= 0.0025 \\ \sum B1 + C1 + D1 + \dots + L1 &= 1 \end{aligned}$$

The application described herein consists of an Excel spreadsheet in which row 3 contains the names of ingredients typically used in poultry rations ( corn, wheat , soybean meal, barley, wheat bran, protein concentrate , lime, salt, di-calcium phosphate, vitamin and minerals premix, and oil) with chemical compositions according to the National Research Council(1994) (Figure 1). In row 1 , cells B1 to L1 contains the ratio of ingredients in the optimal least cost ration as decimal fractions ,whereas in row 2 , cells B2 to L2 contains the ratios of ingredients in the optimal least cost ration as percentages , and in row 4 , cells B4 to L4 show the cost of each ingredient , and cells M1 and M2 show the summation of the components of the optimal ration , which must be 1 and 100, respectively. In rows 6 to 15 , cells B to L contains the ingredients contents in terms of metabolizable energy (ME), crude protein (CP) , lysine(Lys) , methionine plus cystine (M+C) , calcium(Ca) , available phosphorus (Av Ph) , crude fiber (CF) , and ether extract (EE), respectively . In column M , cells M6 to M15 contains the nutrients contents of the optimal ration after equation solution, i.e. the least cost ration contents with respect to ME , CP, Lys, M+C Ca, Av Ph, CF, and EE, respectively . In cells N6 to N15 in column N the symbol of  $\leq$  or  $\geq$  is used to indicate the minimum or maximum level of that nutrient in the desired ration. Cells O6 to O15 in column O show the constraints of the optimal ration with

regards to ME (min & max) , CP (min & max), Lys, M+C , Ca, Av Ph , CF, and EE, respectively , whereas cells M16 and O16 indicate the constraint for the sum of optimal ration content which must be 1. To use the application, the user must enter the constraints of the required nutrients in the optimal ration particularly the minimum and maximum levels of ME and CP in cells O6 ,O7, O8, and O9, respectively whereas the basic contents of Lys, M+C, Ca, Av Ph, CF , and EE, can be retained , and if necessary , altered at a later stage, as shown in column O . After entering the required levels such a minimum of 3100 and maximum of 3200 for ME, 23% and 24% as minimum and maximum for CP, 0.9% Lys, 0.65% M+C , 1% Ca, and 0.4 % Av Ph , as minimums and 5% CF , and 6% EE as maximums , the pointer is placed in cell M4 which called the target cell or the optimal ration cost cell , and the Solver button is clicked in the ribbon menus . This opens the Solver Parameters dialog box, which had previously been set with requisite information including target cell and constraints. The Solve button in this dialog box is then clicked, which opens the Solver Results dialog box containing three reports: Answer, Sensitivity, and Limits report(Figure3). The Results shown in bold font in the dialog box indicate that the formula has been solved, whereas if the results shown in pale font indicate that some of the constraints need to be altered to find a solution. When a solution of the formula is found the option "Keep Solver Solution" can be selected which saves the solution as a new sheet .The first report contains the percentages of the components of the optimal ration , and the second provides information regarding the sensitivity of the solution ie how the solution could be altered if the constraints are changed. The solution of the formula appears

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automatically in row 2 as fractional data and in row 3 as percentages, as shown in Figure 1.

### RESULTS AND DISCUSSION

Figure 1 shows an example of the application where the chemical composition of ingredients was set according to NRC(1994) data and the constraints of nutrients in the desired ration where as follows : a minimum and maximum of 3100 and 3200 Kcal/kg for ME, a minimum and maximum of 23% and 24% for CP respectively , Lys 0.9% , M+C 0.65% , Ca 1% , and Av Ph 0.4% , as minimum values , CF 5% , and EE 6% , as maximum values as in column O. Additional constraints include minimum and maximum of protein concentrate levels as 5% and 10% respectively, a salt level equal to 0.25%, and premix equal to 0.25%. After setting this information the cursor is placed in cell M4 and the Solver button in the (ribbon menus) is clicked then the Solver Parameter dialog box appears as shown in Figure 2. Having done this, the Solve button in this dialog box is clicked to open the Solver Result dialog box showing three reports (Answer, Sensitivity, and Limits) , which appears on the right side of the dialogue box . If these reports names are in bold font , it indicates that the operation has been successful, whereas if they are in pale font as shown in Figure 4 , indicates that the programming model cannot be solved , and in particular that a decrease in some of the nutrients constraints such as CP, amino acids, or minerals, must be changed , , in order for the application to find a solution. Figure 1 shows a successful attempt to identify the optimal ration under the constraints shown in column O, and in this case, the optimal ration consists of 17.44% corn, 40.53% wheat, 31% soybean meal, 5% PC, 1.19% lime , 0.25% salt, 0.626% di calcium phosphate, 0.25% premix, and 3.69% oil,

and contains 3100 Kcal/kg ME , 23% CP, 1.23% lys, 0.75% M+C, 1%Ca ,0.4% Av Ph, 3.54% CF, and 6% EE, and contains 3100 Kcal/Kg ME , 23% CP, 1.23% lys, 0.75% M+C, 1%Ca, 0.4% Av Ph , 3.55% CF, 6% EE , and its cost 662.72 ID/Kg .

Figure 5. Shows a further example in which the application was used for formulation of layer ration with constraints for 2700-2800 Kcal/Kg ME, 16-17% CP, 0.9% Lys, 0.65% M+C, 3.5% Ca, 0.4% Av Ph,  $\leq 5\%$ CF, and  $\leq 6\%$  EE as indicated in column O, in this case It consists of 23.57% corn, 15.6% soybean meal , 30.58% barley, 10.63% bran, 6.34% PC , 8.78% lime , 0.25% salt , 0.45% di-calcium phosphate , 0.25% premix , and 3.57% oil , and contains 2700 Kcal/kg ME , 17% CP , 0.9% Lys , 0.65% M+C , 3.5% Ca , 0.4% Av Ph , 4.64% CF, and 6% EE , as shown in column M , cells M7 to M16. . and in this case the optimal least cost ration identified by the Solver would cost 568.44 ID/Kg.

### CONCLUSION

The ready-to-use application described herein, based on the Solver Add-in function in the Excel program can be used to formulate low cost poultry diets that provide the desired nutritional requirements for poultry. Given its relative ease of use without extensive prior training and its reasonable cost compared with more expensive formulations software, this application should prove to be extremely useful for researchers and students with an interest in diet formulation.

**Figure (1):** The main spreadsheet of the Excel application

|           | A        | B     | C     | D    | E      | F     | G      | H    | I     | J     | K      | L    | M      | N | O  |
|-----------|----------|-------|-------|------|--------|-------|--------|------|-------|-------|--------|------|--------|---|----|
| <b>1</b>  | SOL      | 0.174 | 0.405 | 0.31 | 0      | 0     | 0.05   | 0.01 | 0.003 | 0.006 | 0.0025 | 0.04 | 1      |   |    |
| <b>2</b>  |          | 17.44 | 40.53 | 31   | 0      | 0     | 5      | 1.19 | 0.25  | 0.626 | 0.25   | 3.69 | 100    |   |    |
| <b>3</b>  | INGREDIE | corn  | wheat | sbm  | barley | bran  | P.conc | lime | salt  | dcp   | premix | oil  |        |   |    |
| <b>4</b>  | COST     | 500   | 450   | 750  | 350    | 250   | 1750   | 250  | 100   | 500   | 4500   | 1500 | 662.72 |   |    |
| <b>5</b>  |          |       |       |      |        |       |        |      |       |       |        |      |        |   |    |
| <b>6</b>  | ME       | 3340  | 3100  | 2640 | 2820   | 1680  | 2200   | 0    | 0     | 0     | 0      | 9000 | 3100   | ≥ | 31 |
| <b>7</b>  | ME       | 3340  | 3100  | 2640 | 2820   | 1680  | 2200   | 0    | 0     | 0     | 0      | 9000 | 3100   | ≤ | 32 |
| <b>8</b>  | CP       | 9.03  | 11.7  | 47.3 | 10.72  | 15.86 | 40     | 0    | 0     | 0     | 0      | 0    | 23     | ≥ | 23 |
| <b>9</b>  | CP       | 9.03  | 11.7  | 47.3 | 10.72  | 15.86 | 40     | 0    | 0     | 0     | 0      | 0    | 23     | ≤ | 24 |
| <b>10</b> | LYS      | 0.38  | 0.32  | 2.9  | 0.38   | 0.63  | 2.75   | 0    | 0     | 0     | 0.5    | 0    | 1.2344 | ≥ | 0. |
| <b>11</b> | M+C      | 0.2   | 0.44  | 1.36 | 0.4    | 1.14  | 2.3    | 0    | 0     | 0     | 0.7    | 0    | 0.7519 | ≥ | 0. |
| <b>12</b> | CA       | 0.04  | 0.1   | 0.23 | 0.24   | 0.04  | 6.5    | 32.4 | 0     | 27.1  | 0      | 0    | 1      | ≥ | 1  |
| <b>13</b> | AV PH    | 0.08  | 0.13  | 0.22 | 0.17   | 0.2   | 3      | 0    | 0     | 18.39 | 0      | 0    | 0.4    | ≥ | 0. |
| <b>14</b> | CF       | 2.01  | 3.35  | 5.37 | 6.5    | 10.63 | 3.5    | 0    | 0     | 0     | 0      | 0    | 3.5492 | ≤ | 5  |
| <b>15</b> | EE       | 4.34  | 2.2   | 1.28 | 1.42   | 4.05  | 6      | 0    | 0     | 0     | 0      | 99   | 6      | ≤ | 6  |
| <b>16</b> |          |       |       |      |        |       |        |      |       |       |        |      | 1      | ≤ | 1  |

Figure(2):The solver Parameters dialog box

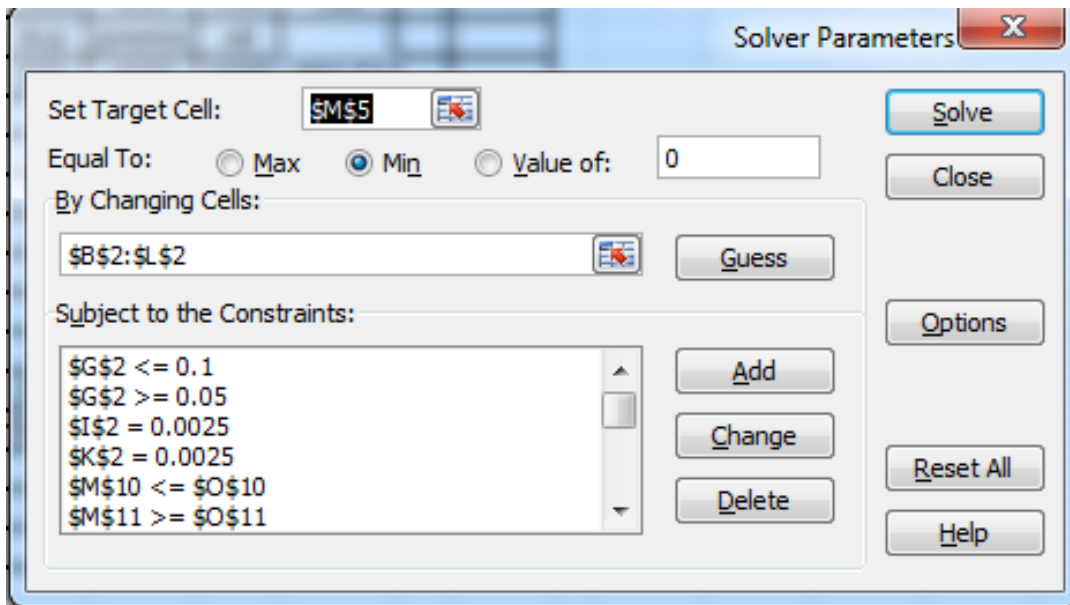
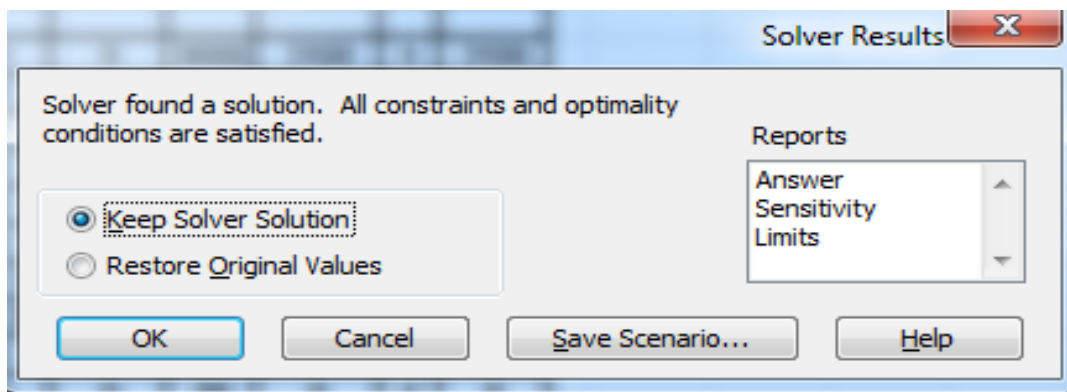


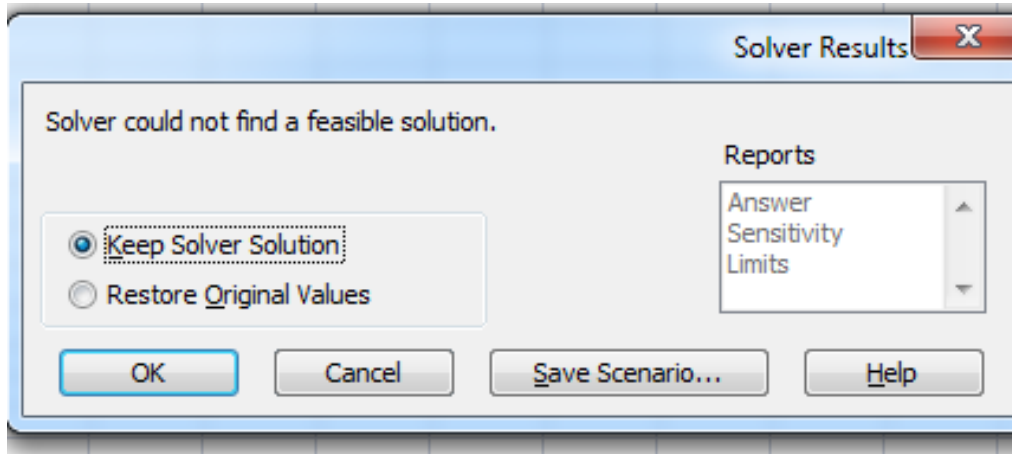
Figure (3): The solver results dialogue box



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**Figure(4):** Solver results dialogue box when a solution could not be obtained .



**Figure (5):** The Solver Result dialogue box for formulation of layer ratio.

|    | A        | B     | C     | D    | E      | F      | G      | H    | I     | J     | K      | L    | M      | N | O    |
|----|----------|-------|-------|------|--------|--------|--------|------|-------|-------|--------|------|--------|---|------|
| 1  | SOL      | 0.236 | 0     | 0.16 | 0.306  | 0.1063 | 0.06   | 0.09 | 0.003 | 0.005 | 0.0025 | 0.04 | 1      |   |      |
| 2  |          | 23.57 | 0     | 15.6 | 30.58  | 10.63  | 6.34   | 8.78 | 0.25  | 0.454 | 0.25   | 3.57 | 100    |   |      |
| 3  | INGREDIE | corn  | wheat | sbm  | barley | bran   | p conc | lime | salt  | dcp   | premix | oil  |        |   |      |
| 4  | COST     | 500   | 450   | 750  | 350    | 250    | 1750   | 250  | 100   | 500   | 4500   | 1500 | 568.44 |   |      |
| 5  |          |       |       |      |        |        |        |      |       |       |        |      |        |   |      |
| 6  | ME       | 3340  | 3100  | 2640 | 2820   | 1680   | 2200   | 0    | 0     | 0     | 0      | 9000 | 2700   | ≥ | 2700 |
| 7  | ME       | 3340  | 3100  | 2640 | 2820   | 1680   | 2200   | 0    | 0     | 0     | 0      | 9000 | 2700   | ≤ | 2800 |
| 8  | CP       | 9.03  | 11.7  | 47.3 | 10.72  | 15.86  | 40     | 0    | 0     | 0     | 0      | 0    | 17     | ≥ | 16   |
| 9  | CP       | 9.03  | 11.7  | 47.3 | 10.72  | 15.86  | 40     | 0    | 0     | 0     | 0      | 0    | 17     | ≤ | 17   |
| 10 | LYS      | 0.38  | 0.32  | 2.9  | 0.38   | 0.63   | 2.75   | 0    | 0     | 0     | 0.5    | 0    | 0.9    | ≥ | 0.9  |
| 11 | M+C      | 0.2   | 0.44  | 1.36 | 0.4    | 1.14   | 2.3    | 0    | 0     | 0     | 0.7    | 0    | 0.65   | ≥ | 0.65 |
| 12 | CA       | 0.04  | 0.1   | 0.23 | 0.24   | 0.04   | 6.5    | 32.4 | 0     | 27.1  | 0      | 0    | 3.5    | ≥ | 3.5  |
| 13 | AV PH    | 0.08  | 0.13  | 0.22 | 0.17   | 0.2    | 3      | 0    | 0     | 18.39 | 0      | 0    | 0.4    | ≥ | 0.4  |
| 14 | CF       | 2.01  | 3.35  | 5.37 | 6.5    | 10.63  | 3.5    | 0    | 0     | 0     | 0      | 0    | 4.6497 | ≤ | 5    |
| 15 | EE       | 4.34  | 2.2   | 1.28 | 1.42   | 4.05   | 6      | 0    | 0     | 0     | 0      | 99   | 6      | ≤ | 6    |
| 16 |          |       |       |      |        |        |        |      |       |       |        |      | 1      |   | 1    |



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الملخص العربي

استخدام برنامج مايكروسوفت اكسل لتكوين علائق الدواجن بواسطة البرمجة الخطية

رافع محمد طاهر خليل

قسم الانتاج الحيواني كلية الزراعة والغابات جامعة الموصل العراق

. تمثل التغذية ما يقرب من 70 ٪ من تكاليف إنتاج الدواجن ، وبالتالي فإن صياغة علائق الدواجن الأقل تكلفة التي توفر المتطلبات الغذائية للطيور هي هدف مهم في إنتاج الدواجن. تهدف هذه الدراسة الى إنشاء تطبيق في برنامج Excel لصياغة علائق الدواجن الأقل كلفة التي توفر الاحتياجات الغذائية الكافية باستخدام البرمجة الخطية اعتمادا على خاصية Solver لبرنامج Excel وباستخدام المواد العلفية الشائعة في علائق الدواجن مثل (الذرة الصفراء ، القمح ، فول الصويا ، الشعير ، نخالة القمح ، مركز البروتين ، حجر الكلس ، ملح الطعام ، فوسفات ثنائي الكالسيوم ، بريمكس الفيتامينات والمعادن ، الزيوت النباتية) ، إذا كانت أسعارها الافتراضية هي 500 ، 450 ، 750 ، 350 ، 1750، 250، 250 ، 100 ، 500 ، 4500 ، و 1500) دينار عراقي / كجم ، على التوالي. أظهرت النتائج أن وظيفة Solver في برنامج Excel يمكن استخدامها لحل نماذج البرمجة الخطية مثل تلك المستخدمة لصياغة علائق الدواجن الأقل تكلفة. تطبيق Microsoft Excel هذا جاهز للاستخدام ويمكن استخدامه لمساعدة الباحثين والطلاب في صياغة علائق الدواجن التي توفر المتطلبات الغذائية المطلوبة للدواجن بأقل تكلفة .  
كلمات مفتاحية : تطبيق ، اكسل ، دواجن ، علائق