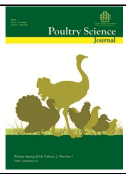

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Choosing a Commercial Broiler Strain Based on Multicriteria Decision Analysis

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Abstract

With the complexity and amount of information in a wide variety of comparative performance reports in poultry production, making a decision is difficult. This problem is overcomed only when all data can be put into a common unit. For this purpose, five different decision making analysis approaches including Maximin, Equally likely, Weighted average, Ordered weighted averages and Technique for order preference by similarity to ideal solution were used to choose the best broiler strain among three ones based on their comparative performance and carcass characteristics. Commercial broiler strains of 6000 designated as R, A, and C (each strain 2000) were randomly allocated into three treatments of five replicates. In this study, all methods showed similar results except Maximin approach. Comparing different methods indicated that strain C with the highest world share market has the best performance followed by strains R and A.

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Introduction

All products and processes used in our daily life are the results of a series of decisions, many of which are made by engineers. Decision-based design takes the perspective that an engineering design and optimization process can be viewed as a set of decisions, which can be modeled and solved in order to provide effective decision support for engineers (Shupe, 1988). The fundamental phases of decision-based design are to determine all possible alternative designs and then choosing the best one (Hazerding, 1998). There are many methods rooted in innovative thinking and creative problem solving that may be used to determine a possible alternative design. Most of the time, we measure several attributes that are related to our exam in poultry research, but when we want to make a decision, it can be found that each of these attributes has different scales and directions. This difference is associated with various preferences of the researcher that lead to the problem in decision making.

There are several methods of multiattribute decision making. Roush and Cravener (1990) compared four Multicriteria decision analysis methods to choose the best commercial laying hen strain. The decision was based on Maximin, Equally likely averaging, Weighted averaging and Ordered weighted averaging. They concluded that in three of four weighted decision, the same strain of hen proved to be the best choice. Another method of multiattribute decision making is technique for order preference by similarity to ideal solution (TOPSIS). The ideal point is defined as the most desirable, weighted and hypothetical alternative (decision outcome). In our recent work, the performance of laying hen fed different levels of yeast was compared using the scoring method (Meimandipour *et al*., 2012). This study showed that TOPSIS seems to be a more scientific test since the weighing procedure is based on the entropy method and the decision maker does not influence the result. It appears that TOPSIS as another good multiattribute decision making has the potential to be applied in many areas of poultry production, including choosing strain, purchasing equipment or property and assessing investment and genetic selection decisions.

Therefore, the present study aimed to find the best commercial broiler strain among the three strains which are routinely used by local farmers. In the current study besides Maximin, Equally likely averaging, and Weighted averaging; Ordered weighted averaging, and TOPSIS were also used.

Materials and Methods

Seven thousand eggs were collected from three different commercial breeder farms (aged from 35-40 weeks), taken to the local hatchery and set in an incubator. The breeder farms were under normal condition regarding hygiene and state of health. After hatching, three commercial broiler strains of 6000 designated as R, A, and C (2000 from each strain) were housed on the floor covered with litter and assigned to three treatments with five replicates each of 400 birds. Chicks were reared under common temperature and humidity and were fed a similar mash diet.

Feed consumption (g/d), mortality (%), weight gain (g/d) and feed conversion ratio were measured. Chicks were weighed individually, while feed consumption was measured weekly over the 6 week experiment and cumulative feed to gain ratio was also calculated weekly (FI/WG). Finally at the end of experiment (42 days), 10 chickens were randomly slaughtered from each replicate and the carcass (%), breast (%) and drumstick (%) were measured.

Decision analysis

For choosing among several alternatives, decision analysis technique can be used. A good manager decides based on all available data and possible alternatives. Taking decision based on decision analysis techniques is not always good. In fact, in some cases, decision making according to the manager's perception has a more desirable outcome than a decision based on the most complicated decision processes. However, over a long period, decision analysis will give more successful results than an impulsive approach (Roush and Cravener, 1990). In decision analysis, a decision is made by 1) identifying the production criteria to consider in the decision 2) selection of alternative ways to evaluate these responses 3) determining the importance of each production criterion 4) determining how each strain performs and finally 5) detecting the best strain.

Multicriteria decision example

Three commercial strains of broiler and the eight performance traits (criteria) are shown in Table 1. The commercial broiler strains are identified by letters R, A and C. The following mathematical relationship relates performance criteria to the fuzzy concept of desirability (Equation 1).

$$\mu S = \text{S-min(S)}/(\max(S)-\min(S)) \qquad (1)$$

Where μS represents the desirability values of members of the fuzzy set S. min(S) and max (S) are the minimum and maximum values, respectively, in the fuzzy set S. For example, to express fuzzy concept of body weight for strain R, the following procedure was followed. First, the set S of values for body weight (S_{BW}) is identified from Table 1:

S_{BW} = {2037, 1959, 2139}.

The maximum and minimum values are then identified: max (S_{BW}) = 2139 and min (S_{BW}) = 1959. These values represent the most desirable and least desirable body weight values relative to the other values in the set. From the equation given above for the membership value (S), the membership value of body weight for strain R is calculated as follows:

S_{2037}= (2037-1959) / (2139-1959)=0.433
When all of the values are calculated for the set S_{BW}, the result is as follows:
S_{BW}= {0.433, 0.000, 1.000}
These membership values, which represent the desirability of body weight for each strain of broilers, given in Table 2 together with membership values for all other criteria.

Some of the criteria have a negative relationship with desirability, such as feed conversion ratio. To represent this membership values in a positive manner, the complement of μS was used.

$$\mu S' = 1-(S-\min(S)) / (\max(S)-\min(S)) \quad (2)$$

Or:

$$\mu S' = 1-\mu s \quad (3)$$

The strategy for decision making depends on the needs of the decision maker. Four alternative ways to evaluate production responses were tested: Maximin, Equally likely, Weighted averaging, and Ordered weighted averaging decision analysis.

Table 1. Production criteria at 42 days of age for different commercial strains of broiler used in Iran poultry industry

Criteria	R	A	C
Feed conversion ratio (g:g)	1.85	1.84	1.864
Body weight (g)	2037	1959	2139
Weight gain (g/bird)	44.3	44.3	49.4
Liveability (%)	93.9	88.5	90.9
Production Index[1]	247	226	252
Carcass (%)	69.8	68.4	70.6
Breast(%)	21.1	20.6	21.6
Drumstick(%)	19.87	20.6	19.4

[1]PI= [Livability (%) x Live Weight (g) / Feed Conversion Ratio x Slaughtering Age (day) × 10]

The ideal point methods

In the ideal point method, the alternatives are ranked according to their separation from an ideal point. The ideal point is defined as the most desirable, weighted, hypothetical alternative (decision outcome). The alternative, closest to the ideal point is the best alternative. The separation is measured in terms of metric distance (Janssen, 1992; Malczewski, 1997).

One of the most popular ideal point methods is the TOPSIS developed by Hwang and Yoon (1981). This method involves the following steps:

1. Determination of the set of feasible alternatives.
2. Standardizing each attribute map layer.
3. Defining of the weights assigned to each attribute ($0 \leq w \leq 1$, $\Sigma w = 1$).
4. Constructing the weighted standardized map layer by multiplying each value of the standardized layer by the corresponding weight.

5. Determination of the maximum value for each of the weighted standardized map layers (the values determine the ideal point).
6. Determination of the mean value for each weighted standardized map layer (the values determine a negative ideal point).
7. Using a separation measure, calculate the distance between the ideal Point and each alternative.
8. Using the same separation measure, determine the distance between the negative ideal point and each alternative.
9. Calculation of the relative closeness to the ideal point.
10. Ranking the alternatives according to the descending order of ideal point.

The method provides complete ranking and information on the relative distance of each alternative to the ideal point. In this method, an alternative is treated as an inseparable bundle of attributes, which makes the method an attractive approach when dependency among attributes is difficult to test or verify (Malczewski, 1997).

Results and Discussion

Maximin approach

Maximin approach is one of the decision analyses regularly used (Roush and Cravener, 1990). In this method, the maximum value of all minimum values is used; hence, it is called "Maximin". As shown in Table 2, the decision set (D) was based on the minimum values in each column.

D= (0.00/R, 0.00/A and 0.00/C)

Table 2. Decision matrix based on fuzzy set membership values for the production criteria in table 1

Criteria	R	A	C
Feed conversion ratio (g:g)	0.640	1.000	0.000
Body weight (g)	0.433	0.000	1.000
Weight gain (g/bird)	0.000	0.002	1.000
Liveability (%)	1.000	0.000	0.446
Production Index[1]	0.808	0.000	1.000
Carcass (%)	0.616	0.000	1.000
Breast(%)	0.459	0.000	1.000
Drumstick(%)	0.383	1.000	0.000
Decision			
Miximin	0.000	0.000	0.000
Equally likely	0.482	0.222	0.605

[1]PI= [Livability (%) x Live Weight (g)/Feed Conversion Ratio x Slaughtering Age (day) × 10]

The 0.00/R indicates that the membership value for strain R is 0.00 and so on. In this experiment, the Maximin value for each column is 0.00, therefore according to these method we can not make the final decision. Actually, this kind of decision making analysis is based on single production criteria, and overall performance is not considered. For example, the times that strain R had a full membership in the set were ignored.

In breeding, broiler chickens are selected based on the desired characteristics of the breeder company. In this process, high-intensity selection is based on some traits depending on the importance of characteristics and some other traits have less attention. Therefore, each strain contains at least one minimum value trait in the decision matrix. For these types of models, the best approach is one, which includes all measurements of production responses in the decision process.

Averaging or Equally likely decision

In averaging method, each of the production responses participates in the decision process. Tables 1 and 2 listed nine criteria for various performance traits of different broiler strains. These values are very subjective and could vary according to the bias of a decision maker. In this method, the manager averages the values of performance criteria in each of the columns representing each strain (*e.g.* for strain R, {0.640+0.433+…+0.383}/9=0.482), and then the strain that has the highest average value was chosen (Table 2). In this example, the strain C in comparison with other strains has a higher yield. Rating strains of averaging method would be as follows: C>R>A.

Therefore, according to this method, strain C in comparison to the other strains showed the best performance. Strains R and A get the second and third orders, respectively.

Weighted averaging

Weighted averaging emphasizes the performance criteria that the manager feels are more important than the others. Table 3 shows the chosen values, weight of importance, and normalized weights. First, the weight of importance was determined. The point one was assigned to the least important production criteria namely drumstick percentage in the set. Then the next least important criteria, breast percentage, was assigned to point two; showing how much more important it is, then the least important criteria, and so on, until all criteria were assigned a weight of importance. The total of these weights (36) was determined, and the weights were normalized by dividing the weight of importance for each criterion by this total (Table 3). The weighted membership values of all criteria for all broiler strains are presented in Table 4.

For example, the value for feed consumption of strain R was determined by multiplying the normalized weight from Table 3, 0.167, by the fuzzy membership value from Table 2, 0.640, to obtain 0.107. The calculated values were summed (*e.g.* 0.167+ 0.084 ... + 0.011 = 0.5970) for each strain. The resulting decision set (D), composing of these summed values for each strain, is: D = {0.597/R, 0.195/A and 0.729/C}.

The largest value of the decision set was 0.729, which was the membership value for strain C. The weighted ranking using this decision approach was:
C>R>A.

Therefore, according to this method, strain C in comparison to the others had the best performance. Strains R and A got the second and third orders, respectively.

Table 3. Normalized weights for selecting commercial broiler strain

Criteria	Weight of importance	Normalized weight
Feed conversion ratio (g:g)	6	6/36=0.167
Body weight (g)	7	7/36=0.194
Weight gain (g/bird)	4	4/36=0.111
Liveability (%)	5	5/36=0.139
Production Index[1]	8	8/36=0.222
Carcass (%)	3	3/36=0.083
Breast(%)	2	2/36=0.056
Drumstick(%)	1	1/36=0.028
Total	36	1.000

[1]PI= [Livability (%) x Live Weight (g)/Feed Conversion Ratio x Slaughtering Age (day) × 10]

Table 4. Weighted average of fuzzy set membership values for the production criteria of commercial broiler strains

Criteria	Rank	Weight	R	A	C
Feed conversion ratio (g:g)	6	0.167	0.107	0.167	0.000
Body weight (g)	7	0.194	0.084	0.000	0.194
Weight gain (g/bird)	4	0.111	0.000	0.000	0.111
Liveability (%)	5	0.139	0.139	0.000	0.062
Production Index[1]	8	0.222	0.179	0.000	0.222
Carcass (%)	3	0.083	0.051	0.000	0.083
Breast (%)	2	0.056	0.026	0.000	0.056
Drumstick (%)	1	0.028	0.011	0.028	0.000
Decision			0.597	0.195	0.729

[1]PI= [Livability (%) x Live Weight (g)/Feed Conversion Ratio x Slaughtering Age (day) × 10]

Ordered weighting averaging

Another way to assess production criteria is ordered weighted averaging (Yager, 1988). In this method, apart from the production criteria, the weights of importance are presented in a descending order. These weights put emphasis on the best responses of each broiler strain. Table 5 shows the ordered weighting of production criteria, which is calculated as follows. The normalized weights from Table 3 were put in a descending order (e.g. 0.222, 0.l94 ... 0.028).

The fuzzy membership values from Table 2 for each strain were also put in a descending order (*e.g.* for strain A: 0.938, 0.846 ... 0.028). The ordered weights were then multiplied by the ordered fuzzy membership values (*e.g.* for strain R: 0.222 ×

1.000=0.222, 0.l94 × 0.808 = 0.157, and … 0.028 × 0.00 = 0.000). The values resulting from the multiplication of the weight of importance and the ordered membership value were summed for each broiler strain (*e.g.* for strain R: 0.680), as shown in Table 5. Therefore, the decision set (D) for this analysis was: D = {0.680 / R, 0.417 / A and 0.871 / C}. The largest ordered weighted average of the decision set (0.871) was that of strain C. The ranking of the strains by ordered weighted decision approach was: C>R>A.

Table 5. Ordered weighted averages of fuzzy set membership values for the production criteria of commercial broiler strains

Weight	R	A	C
0.222	0.222	0.222	0.222
0.194	0.157	0.194	0.194
0.167	0.107	0.0003	0.167
0.139	0.085	0.000	0.139
0.111	0.051	0.000	0.111
0.083	0.036	0.006	0.037
0.056	0.021	0.000	0.000
0.028	0.000	0.000	0.000
Decision	0.680	0.417	0.871

Since, these decision approaches are used as the making decision tools; the most suitable method will depend on the existing problems and the manner of the decision maker (Zimmermann, 1987). Thus, none of the mentioned decision methods described above can not be considered as the best method.

The ideal point methods

According to TOPSIS method, decision matrixes based on fuzzy set membership values were set as shown in Table 6.

Table 6. Decision matrix based on fuzzy set membership values for the production criteria in table 1 according to TOSIS method

Criteria	R	A	C
Feed conversion ratio (g:g)	0.026	0.025	0.026
Body weight (g)	0.575	0.553	0.603
Weight gain (g/bird)	0.280	0.280	0.313
Liveability (%)	0.0005	0.0005	0.0005
Production Index[1]	0.589	0.539	0.601
Carcass (%)	0.579	0.568	0.586
Breast (%)	0.574	0.597	0.560
Drumstick (%)	0.576	0.564	0.591

[1]PI= [Livability (%) x Live Weight (g) / Feed Conversion Ratio x Slaughtering Age (day) × 10]

The memberships of the matrix were measured according to the following formula:

$$n_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^{2}}} \qquad (4)$$

Table 7 represents TOPSIS method weighting of the production criteria, calculated as follows.

1. Calculating the probability distribution (Pij) as follows:

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}} \qquad (5)$$

2. Calculating the entropy value (Ei):

$$E_j = -k\sum_{i=1}^{m}[p_{ij} \ln p_{ij}] \qquad (6)$$

3. Calculating the amount of uncertainty (di):

$$d_i = 1 - E_j \qquad (7)$$

Calculating the weights:

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \qquad (8)$$

Table 7. Technique for TOPSIS results of fuzzy set membership values for the production criteria of commercial broiler strains

Weight	Criteria
0.00004	Feed conversion ratio (g:g)
0.14285	Body weight (g)
0.14285	Weight gain (g/bird)
0.14285	Liveability (%)
0.14285	Production Index[1]
0.14285	Carcass (%)
Decision	
0.527	R
0.286	A
0.714	C

[1]PI= [Livability (%) x Live Weight (g) / Feed Conversion Ratio x Slaughtering Age (day) × 10]

Finally, setting the decision set (D) for this analysis was calculated by multiplying the probability distribution (Pij) matrix with weighting matrix according to the matrix multiplication rules. In these methods, the decision set (D) for this analysis was: D = {0.527/R, 0.286/A, and 0.714/C}. The ranking of the strains using TOPSIS method was: C>R>A.

Conclusion

Multicriteria decision analysis is a suitable tool for evaluation of data, which are determined in different units. However, depending on the types of data, the method of analysis can be different. Moreover, the results obtained by the methods of Equally likely, Weighted average, Ordered weighted averages and TOPSIS showed that strain C had the best performance over the course of the experiment which followed by strains R and A. Strain C has the highest world share market.

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