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COMPARISON OF FACTORIAL AND TAGUCHI DESIGNS IN POULTRY SCIENCE DATA

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ABSTRACT

This study was aimed to investigate use of Taguchi method in animal researches which is as an alternative to factorial experiments. Modeling real-world phenomena often requires more than one factor to explain changes on response variables. Factorial designs are very powerful statistical tools because they allow a researcher to simultaneously test the effects of multiple factor-level combinations on response. But sometimes factor numbers and their levels used in the factorial experiments as difficult and expensive. Taguchi method is a design by using orthogonal arrays which minimizes the time and cost of experiment compared with factorial design. Also, reducing the number of experimental units allow to reduce the effects of uncontrollable factors. Particularly, studies to test a large number of its good results at less cost than expanding the use of Taguchi method. Application data taken Erbeyli Fig Research Station Management. Experimental design of data was 3x3x2 factorial design. Factorial experiment and Taguchi method results were compared. Taguchi method was determined the best combination of period, breeding and genotype which had effect on egg weight with a less number of experimental units. Taguchi method which is not commonly used today should be promoted and popularized as an alternative.

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INTRODUCTION

In statistical analysis a common factor in research is investigating the effects of each of factors on a response variable. Factorial experiment is an experiment whose design consists of two or more factors, and whose experimental units take on all possible combinations of these levels across all such factors. In the factorial approach, investigator compares all treatments that can be formed by combining the levels of the different factor variables. For the experimental studies, indispensable elements of science and research, to reach the true results can be achieved by the selection of correct and appropriate statistical analysis method. The accomplishment of designs requires intensive work. Researches aim to find new approaches in order to save in terms of time and cost. Today, the demand for food due to the rapidly increasing population, industry and technology brings new methods and approaches for obtaining the most fruitful products with high quality in agriculture.

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These approaches employed in agriculture cost a lot due to the modern technology and machines used and take too much time as well. In the studies conducted, new experiment designs have been attempted to be developed rather than leading to high cost. The foundations of variance analysis were introduced by Fisher *et al*. in 1920s. In the following years, the analysis of complex test plans became possible. Fisher stated that the best interpretation style was the ANOVA (Lazic, 2004; Cochran and Cox, 1992). The factor number affecting the result in agricultural studies was encountered usually more. Agricultural materials, product diversity and farm management mechanization require the comparison of a large number of factors. The number of variables affecting the result in animal experiments is usually more than one. The abundance in the number of combinations in costly studies seems to be a disadvantage. After observing these difficulties, Dr. Taguchi wanted to decrease the number of experimental combinations of the studies (Nellian, 1996). The study was conducted to investigate the effect of factors on egg weight- a vital yield criterion- by using Taguchi method and to determine the effective parameters. The evaluation of the results was supposed to bring about the development of practical applications in costly animal experiments.

MATERIALS AND METHODS

The data for application of this study was taken from a research conducted on egg weight in Erbeyli Fig Research Station Management. The animal material of the study was 800 commercial slow-growing broilers line (Hubbard Red-JA) and of 400 chicks of commercial fast-growing broilers line (Ross 308), each having 2 different genotypes with mixed ages and genders. The maturation periods of the mentioned chicks were analyzed in three different periods: 14-week chicks, 15-28-week chicks and 29-42-week chicks.

Two different breeding systems were employed in the study, one being conventional and the other organic. In the study, by using two different breeding techniques in three different levels, we aimed to reach the highest productivity with the best combination in chickens with two different genotypes. In the studies on poultry, the number of trials is high. The number of total combinations in this study is 2*2*3=12, and they were carried out with 32 replicates, 12*32 = 384 total experimental units. All two way interaction effects were included in the factorial experimental design for consideration. (Küçükyılmaz *et al*. 2010). This study was evaluated only 12*3=36 experimental units with Taguchi Design experiment. As shown in Table 1, the most appropriate design for this experimental study was chosen to be Taguchi L_{36} orthogonal array. Taguchi L_{36} orthogonal array factors combinations are given in Table 1.

Taguchi method is a method trying to minimize the variation in product and process by choosing the most appropriate combination of controllable factors' levels against uncontrollable factors that lead to change (Canıyılmaz, 2001). The method offers the opportunity of getting good result with less experiment in the increase of quality (Roy, 1990; Ross, 1989). In this method, among the following methods - observation method, ranking method, column differences method and graphical representation of the factor effects - was applied for the determination of the factor levels (Ross, 1989; Canıyılmaz, 2001).

In the Taguchi method, the losses through the deviations of target values from observed values are defined as "Taguchi Loss Function" and could be interpreted by converting into Signal/Noise (S/N) ratio. As the S/N ratio increases, the product variability (variance) around the target decreases. The calculation of S/N requires three different functions for determining the targeted value of quality. These are: nominal value the best, the biggest the best, and the smallest the best S/N ratios. No matter which case is used, the level with the highest S/N ratio is the level that determines the best performance that is the productivity.

When the result known as performance characteristic is the lowest the best,

$$S/N = -10 * \log_{10} [(1/n) * \Sigma y_i^2]$$

Table 1. L_{36} levels of the parameters used in the experiment, the experimental design

Number of experimental unit	Breeding	Genotype	Period	Egg weight
1	1	1	1	61.28365
2	1	1	2	63.57563
3	1	1	3	65.45842
4	1	1	1	61.28365
5	1	1	2	63.57563
6	1	1	3	65.45842
7	1	1	1	61.28365
8	1	1	2	63.57563
9	1	1	3	65.45842
10	1	2	1	60.84177
11	1	2	2	62.12510
12	1	2	3	64.43519
13	1	2	1	60.84177
14	1	2	2	62.12510
15	1	2	3	64.43519
16	1	2	1	60.84177
17	1	2	2	62.12510
18	1	2	3	64.43519
19	2	1	1	60.69320
20	2	1	2	63.43911
21	2	1	3	65.21573
22	2	1	1	60.69320
23	2	1	2	63.43911
24	2	1	3	65.21573
25	2	1	1	60.69320
26	2	1	2	63.43911
27	2	1	3	65.21573
28	2	2	1	59.46635
29	2	2	2	61.43648
30	2	2	3	63.82206
31	2	2	1	59.46635
32	2	2	2	61.43648
33	2	2	3	63.82206
34	2	2	1	59.46635
35	2	2	2	61.43648
36	2	2	3	63.82206

Table 2. Different levels of the orthogonal factor indexes (Yilmaz, 1999)

Orthogonal Arrays (OA)	Number of factors	Levels of factors	Number of experiment for OA	Number of experiment for full factorial design
L4(2^3)	3	2	4	8
L8(2^7)	7	2	8	128
L9(3^4)	4	3	9	81
L12(2^{11})	11	2	12	2048
L16(2^{15})	15	2	16	32768
L16(4^5)	5	4	16	1024
L18(2^1*3^7)	17	23	18	4374

Table 3.Egg weight of the factors affecting the S / N ratio and mean

S/N ratios				Means			
Level	Breeding	Genotype	Period	Level	Breeding	Genotype	Period
1	35.98	36.02	35.64	1	62.95	63.28	60.57
2	35.89	35.85	35.94	2	62.35	62.02	62.64
3			36.22	3			64.73
Delta	0.09	0.17	0.58	Delta	0.61	1.26	4.16
Rank	3	2	1	Rank	3	2	1

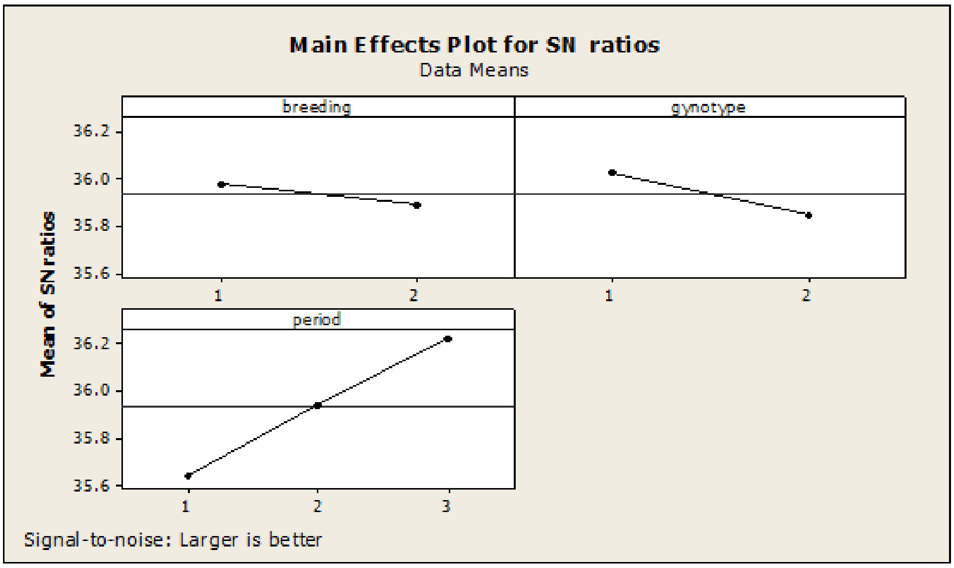

Figure 1. Egg weight S / N ratio parameters for the effective factor levels

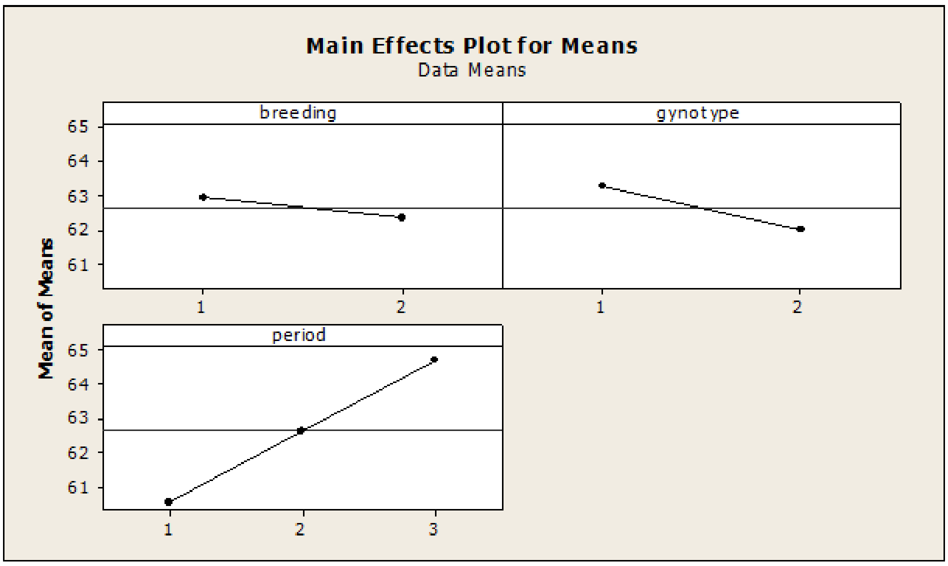

Figure 2. Egg weight mean values according the effective factor levels

When the highest is the best:

S/N= -10 * $\log_{10}$[(1/n) * $\Sigma(1/y_i^2)$]

When nominal is the best:

S/N= $\log_{10}$[$\overline{y}^2 / s^2$] formulas are used.

RESULTS AND DISCUSSION

In the study conducted, the biggest the best approach was chosen in S/N ratio. Results, in line with this ratio, are presented in Table 3. Table 3, obtained in accordance with Taguchi method, states the rank values and order levels of importance of the variables. Accordingly, while period is the most important factor, breeding is supposed to be the least effective one. At the same time, it could be observed what levels of the variables constitute the best combination. In line with the results obtained, the biggest S/N value among these values indicates the most appropriate level. As shown in Table 3, the 1st levels of the breeding and genotype and 3rd level of the period makes the best combination. The similar interpretations could be made when the means are analyzed. The graphical results of the factor effects are provided in Figure 1 and Figure 2. As presented in Figure 1 and Figure 2, the 1st levels of the breeding and genotype and 3rd level of the period formed the best combination as graphical interpretation method.

Conclusions and Recommendation

With regard to time and cost, scientific methods should be employed in agricultural applications for this purpose; experimental designs play key roles for increasing the production and quality. In the analysis of the results, finding alternative approaches is beneficial. Each method can produce good results within its borders, but the graphical analysis and interpretation of data through Taguchi method is easier than ANOVA method (factorial experiment). The study on egg weight was conducted through factorial experimental design along with 4608 experimental units. In this study, similar results were obtained through Taguchi method with only 36 experimental units. The study on egg weight was conducted through factorial experimental design along with 4608 experimental units. In this study, through Taguchi method, similar results were obtained with only 36 experimental units. In terms of cost and time, this result offers a great advantage to the researchers. Through Taguchi method, the best combination of period, breeding and genotype which had effect on egg weight was determined. At the same time, the similar results were obtained through a less number of experimental units. The Taguchi method which is not commonly used today should be promoted and popularized as an alternative method.

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