Investigation of Red Meat Production in Turkey by ANOM Test

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Abstract: When comparing more than two groups means, the analysis of means (ANOM) can be used as an alternative to the one-way analysis of variance (ANOVA) F test. The ANOM provides a “confidence interval type of approach” that allows it to determine which, if any, of the x groups has a significantly different mean from the overall average of all the group means combined. The aim of this study was to show the application of a statistical technique (ANOM), mostly used by agriculture, to determine differences between red meat production by period in Turkey. The production quantities of goat meat, mutton, buffalo meat and beef between the years 2010 and 2016 according to the period were taken from Turkish Statistical Institute (TSI). As a result, the difference between meat productions was found to be significant.

Key words: ANOM test, meat production, period.

1. Introduction

Meat is one of the most beneficial foods from a nutritional line of sight [1]. Meat products have been implicated in many cases of foodborne illness [2]. Briefly, cattle, buffalo, sheep and goat meat are red meat, while chicken and turkey meat is white meat. Accurate numbers on red meat production are important for progressive countries, because consumption of meat has a well-established strong, positive relationship with the level of economic development [3]. According to the United Nations Food and Agriculture Organization (FAO) 2014 statistics, in the ranking of countries, Turkey was ranking the 4th in sheep meat production, the 3rd in goat meat amount, the 11th in cattle meat and the 22nd in buffalo meat production in the world [4]. According to this information, Turkey is a very important country in the world in terms of red meat production. According to statistics of Turkey Statistics Institution (TSI) on red meat production data, quantity of sheep, goat, cattle and buffalo meat production are 82,485,000, 31,011,000, 1,059,195,000 and 351,000

tones, respectively, in 2016 [5].

In various studies, it is desirable to determine the effect of multiple groups for a particular feature. Analysis of means (ANOM) test is important in terms of graphically presenting these effects more visually.

ANOM method can be considered as a special case of a much extensive statistical concept known as multiple contrasts tests [6]. Ott [7] developed a graphical representation for the test and introduced the term analysis of means. Korbar et al. [8] demonstrated the analytical use of a statistical tool ANOM, mixed model analysis and other statistical tools to investigate differences found in Croatian high school student performance in mathematics examinations [8]. Balamurali and Kalyanasundaram [9] reported that the ANOM is sometimes referred to as an alternative to the one-way analysis of variance (ANOVA) [9].

ANOM tests are relatively simple to perform and they allow the user to assess practical and statistical significance by graphically demonstrating differences in a decision chart. The assumptions for ANOM are identical with those for the ANOVA F test [10]. Originally studied by Laplace in 1827, ANOM has become a common approach to identifying any group

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that is performing differently from the rest.

ANOM is a graphical analogue to ANOVA, and tests the equality of population means. ANOM can also be used as a multiple comparison test. ANOM, however, compares each treatment mean to the overall mean, while the Tukey, Duncan, SNK tests consider pair wise differences between the means. The ANOM is performed by computing UDL (upper decision line) and LDL (lower decision line) and checked to see whether any of the means fall outside decision lines or not [11].

However, there was no study on red meat production using the ANOM test. Thus, this study aimed to investigate the red meat production between the years 2010 and 2016 in Turkey according to periods using ANOM test.

2. Materials and Methods

The production quantities of goat meat, mutton, buffalo meat and beef between the years 2010 and 2016 according to the 1st, 2nd, 3rd and 4th term, were taken from the website of Turkish Statistical Institute (TSI) [12]. The four different periods in a year are divided as follows: first three months of the year as the 1st period, the second quarter of the year as the 2nd period, the third quarter of the year as the 3rd

period and the last three months of the year as the 4th period.

ANOM test can be used to test the hypothesis $H_0 = \mu_1 = \mu_2 = \dots = \mu_k$ versus the alternative H_1 : at least one of the μ_i is distinctly different as well ANOVA test. ANOM compares each treatment mean to the overall mean, and tests whether the treatment means are different from the grand mean [13]. The steps of ANOM test are given Table 1.

Using the ANOM to test the hypothesis H_0 (null hypothesis) versus the H_1 (alternate hypothesis) both answers whether there are any differences among the treatment means, and if there are differences, how the treatment means differ [13, 14].

3. Results and Discussion

The ANOM test was applied to test the significance of difference between the amounts of goat, mutton, buffalo meat and beef in the period between 2010 and 2016 in Turkey. Numbers of treatment groups are four (goat, mutton, buffalo meat and beef) and the sample size for each treatment group are seven, so the total number of observation are 28. The ANOM test was performed with the Minitab package program.

First, the Levene test was performed to test the homogeneity of the variances. The P values were found

Table 1 Steps of ANOM test.

Calculated variables	Formulas
Treatment means	$\bar{Y}_i = \frac{\sum_{l=1}^N Y_{li}}{N}$
The overall mean	$\bar{Y} = \frac{\bar{Y}_1 + \bar{Y}_2 + \dots + \bar{Y}_k}{k}$
Sample variances	$S^2 = \frac{\sum_{i=1}^N (Y_i - \bar{Y})^2}{N - 1}$
MSE	$MSE = \frac{\sum_{i=1}^N (n_i - k) S_i^2}{N - k}$
UDL for unequal sample size	$UDL = \bar{Y} + h(n, k, N - k) \sqrt{MSE} \sqrt{(k - 1)/N}$
LDL for unequal sample size	$LDL = \bar{Y} - h(n, k, N - k) \sqrt{MSE} \sqrt{(k - 1)/N}$
UDL for equal sample size	$UDL = \bar{Y} + h(n, k, N - k) \sqrt{MSE} \sqrt{(N - n_i)/N_{ni}}$
LDL for equal sample size	$LDL = \bar{Y} - h(n, k, N - k) \sqrt{MSE} \sqrt{(N - n_i)/N_{ni}}$

MSE: mean square error; UDL: upper decision line; LDL: lower decision line.

In these formulas, N is the total number of observation; k is the number of treatment groups, n_i is the sample size for the i th group; $h(n, k, N - k)$ is the critical values based on significance level (α), number of means being compared (k) and degrees of freedom for means square error ($N - k$).

as 0.436, 0.068, 0.883 and 0.452, respectively, in the Levene test applied for the data of goat meat, mutton, buffalo meat and beef. The group variances are homogeneous since $P > 0.05$ (Fig. 1). Therefore, ANOM test could be applied.

The ANOM test results are given in Fig. 2. From Fig. 2, it is seen that goat meat production amounts in the 4th period exceeded the confidence interval, while the amount of goat meat production in the other periods was within the confidence interval. Also it is seen that there is no statistically significant difference between the amounts of goat meat produced in the 1st, 2nd and 3rd periods, but, the amount of goat meat produced in the 4th period is much higher than that in

other periods. However, the amount of goat meat produced in the 2nd period is very close to the lower limit of the confidence interval. The lowest goat meat production was realized in the 2nd period. The amount of mutton production in the 1st and 4th periods exceeded the confidence interval. Mutton was produced in the 4th period at the most, and in the 1st period at the least. The values of buffalo meat production are within the confidence interval for all periods. In other words, the production of buffalo meat did not show any significant change on period basis. The amount of beef production exceeded confidence interval in the 4th period. Beef was produced in the 4th period at the most, and in the 1st period at the least.

Fig. 1 Levene's test results for meat production.

Fig. 2 ANOM Chart for meat production.

Estimation of red meat production was conducted to take into account changes in the inventory of animals, net foreign trade, the death loss among mature animals, and the carcass weight of slaughtered animals by new estimation approach [15]. European Union accession process of Turkey had tried to analyze the potential impact on the livestock sector under various future predictions [16]. Akgul and Yildiz [17] made the 2016-2023 period of Turkey red meat production predictions by analysis of time series, and obtained autoregressive integrated moving average model (ARIMA).

4. Conclusion

Beef, mutton and goat meat are the most produced in the 4th period, while the buffalo meat is the most produced in the 2nd period. According to periods, the difference between meat productions was found to be significant. The ANOM test is advantageous in terms of practicality graphical representation. The ANOM

graph is easy for non statisticians to understand. This study is useful to show the comparison of different groups in the field of animal husbandry.

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