INTRODUCTION

The nonlinear regression utilizes the ordinary least squares method for mathematically fitting the nonlinear curve of the Luong model. However, the use of statistical tests to choose the best model relies heavily on the residuals of the curve to be normally distributed, of equal variance (homoscedastic) and random. Nevertheless, the usage of statistical tests to select the ideal model depends heavily on the residuals of the curve to generally be normally distributed, of equal variance (homoscedastic) and random. One of many assumptions of parametric-based nonlinear regression is that the within-group variances of the groups are all the same (exhibit homoscedasticity). If the variances are different from each other (exhibit heteroscedasticity), then the model is not statistically adequate to explain the data [1]. Several tests are available to check the equality of variances on residual data from three or more samples and include those of Cochran, Bartlett, Brown–Forsythe and Levene; the F-test is used to check for homogeneity of two variances.

The equality of variance or homoscedasticity can be presented and assessed visually roughly in the form of a residual graph where evidence of possible heteroscedasticity can be ascertained from the points dispersion around the central line that tends to increase as the concentrations were increased. Under this condition, the variances are not homogeneous. The function of the Bartlett’s and the Levene’s tests is to further confirm this observation [2–4]. In this work, Bartlett’s test would be used to test for homogeneity of variance (homoscedasticity) or equality of variance of the residuals [4–7].
MATERIALS AND METHODS

Acquisition of Data
Data on the growth of the bacterium Burkholderia sp. strain Neni-11 on acrylamide from Figure 6 as modelled using the modified Gompertz model (solid lines) (Fig. 6 from [5] reproduced with permission from Hibiscus Publisher).

Test for equality of variance

Bartlett's test
Bartlett’s test is used to test the null hypothesis, $H_0$, that all k population variances are equal against the alternative that at least the two are different. If there are $k$ samples with size $N_i$, sample variance of the $i$th group $s_i^2$ and $S_p^2$ is the pooled variance and the Bartlett’s test statistic is:

$$ X^2 = \frac{(k-1)\sum_{i=1}^{k}(N_i-1)\ln(s_i^2)}{\sum_{i=1}^{k}(N_i-1) - \frac{1}{k}\sum_{i=1}^{k}(N_i-1)\ln(S_p^2)} \quad (\text{Eqn. 1}) $$

Where $\sum_{i=1}^{k}N_i$ and $\sum_{i=1}^{k}(N_i-1)s_i^2$ are the variance pooled estimate. The test statistics have an approximately $\chi^2$ distribution. The null hypothesis is rejected if $X^2 > \chi^2_{\alpha, k-1}$, where for a $\chi^2$ distribution, $\chi^2_{\alpha, k-1}$ is the upper tail critical value.

Levene’s test
The test statistic, $W$, is defined as follows:

$$ W = \frac{(N-k)\sum_{i=1}^{k}N_i(\bar{Y}_i - \overline{Y})^2}{(k-1)\sum_{i=1}^{k}(N_i-1)(\bar{Z}_{ij} - \overline{Z})^2} \quad (\text{Eqn. 2}) $$

Where,

$\overline{Y}_i$ is the value of the measured variable for the $i$-th group.

$\bar{Z}_{ij} = \begin{cases} |Y_{ij} - \overline{Y}_i|, & \text{if } Y_{ij} \neq \overline{Y}_i \\ \overline{Y}_i, & \text{if } Y_{ij} = \overline{Y}_i \end{cases}$

$\bar{Y}_i$ is a median of the $i$-th group.

$\overline{Y}$ is a mean of the $i$-th group.

The test statistic for the Levene’s test or $W$ is roughly F-distributed and has $N-k$ and $k-1$ degrees of freedom, and hence is the significance of the outcome $w$ of W tested against the quantile of the F-distribution, which is $F$ with $k-1$ and $N-k$ degrees of freedom. The selected level of significance or alpha is usually 0.05 or 0.01.

RESULTS AND DISCUSSION

The Bartlett tests is adequate to test for homogeneity of variance (homoscedasticity) or equality of variance of the residuals [9]. The results of the Bartlett’s test show that the value of $\chi^2$ was at 15.904 and the critical value was 18.31. Using the CHIDIST function from Excel, a probability of 0.188 was obtained (not significant) indicating that there were no real differences between the variances of the residuals.

The Levene’s test gave a p-value of 0.435, also indicating that there were no real differences between the variances of the residuals. Levene’s test for homogeneity of variances [2] is sturdy and it is generally utilized to check out the probable presence of homoscedasticity especially for data coming from 3 or more samples. It is actually much less affected to nonnormality compared to Bartlett's test [4], which needs to be utilized as long as there is certainly persuading proof that the trial outcomes originate from a normal distribution. It is strongly suggested the utilization of the Levene test to evaluate for homogeneity of variances for groups of analytical data.

In conclusion, the test for the homogeneity of variance for the Luong model in fitting of the reduction curve in this bacterium is adequate. The tests statistics carried out in this work is important since if the results obtained violated the homogeneity of variance then a remedy can be made which include transformation of the data by various transformation methods such as the square-root transformation for count data or the log transformation for size data and the Arcsine transformation for proportion data to name a few.

REFERENCES