# Supplementary material

***ANOVA statistical analysis***

## 1. Esterification of oleic acid (OA) with alcohols with different length of carbon chain (C)

### *One-Way ANOVA*

Dependent variable: OA Conversion
Factor: C

Number of observations: 14
Number of levels: 7

A one-way analysis of variance (ANOVA) for OA Conversion was performed. It allows comparing the mean values of OA Conversion for the 7 different levels of carbon chain length (C). The F-test (Table 2) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 4).

Table 1 shows various statistics for OA Conversion for each of the 7 levels of C. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 1.** Summary Statistics for OA Conversion

| *Carbon Long Chain* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* |
|---|---|---|---|---|
| 2 | 2 | 7,98186 | 1,33778 | 16,7603% |
| 3 | 2 | 8,5601 | 0,865151 | 10,1068% |
| 4 | 2 | 21,5003 | 1,87736 | 8,73178% |
| 5 | 2 | 74,1546 | 1,44183 | 1,94436% |
| 6 | 2 | 73,6466 | 3,93704 | 5,34585% |
| 7 | 2 | 63,0872 | 1,27364 | 2,01885% |
| 8 | 2 | 90,7678 | 0,232178 | 0,255794% |
| Total | 14 | 48,5284 | 33,4397 | 68,9077% |

| *Carbon Long Chain* | *Minimum* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|---|
| 2 | 7,0359 | 8,92781 | 1,89191 | | |
| 3 | 7,94835 | 9,17186 | 1,22351 | | |
| 4 | 20,1728 | 22,8278 | 2,65499 | | |
| 5 | 73,1351 | 75,1741 | 2,03906 | | |
| 6 | 70,8627 | 76,4305 | 5,56781 | | |
| 7 | 62,1866 | 63,9878 | 1,8012 | | |
| 8 | 90,6036 | 90,9319 | 0,32835 | | |
| Total | 7,0359 | 90,9319 | 83,896 | -0,283904 | -1,45338 |

The ANOVA table (Table 2) decomposes the variance of Conversion into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 668,702, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean OA Conversion from one level of C to another at the 5% significance level.

**Table 2.** ANOVA Table for OA Conversion by C.

| Source | Sum of Squares | Df | Mean Square | F-Ratio | P-Value |
|---|---|---|---|---|---|
| Between groups | 14511,5 | 6 | 2418,58 | 668,70 | 0,0000 |
| Within groups | 25,3178 | 7 | 3,61683 | | |
| Total (Corr.) | 14536,8 | 13 | | | |

Table 3 shows the mean OA Conversion for each level of C. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each level. Table 3 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 3.** List of Means for OA Conversion by C with 95,0 percent LSD intervals

| | | | Stnd. error | | |
|---|---|---|---|---|---|
| Carbon Long Chain | Count | Mean | (pooled s) | Lower limit | Upper limit |
| 2 | 2 | 7,98186 | 1,34477 | 5,73333 | 10,2304 |
| 3 | 2 | 8,5601 | 1,34477 | 6,31158 | 10,8086 |
| 4 | 2 | 21,5003 | 1,34477 | 19,2518 | 23,7489 |
| 5 | 2 | 74,1546 | 1,34477 | 71,9061 | 76,4031 |
| 6 | 2 | 73,6466 | 1,34477 | 71,3981 | 75,8951 |
| 7 | 2 | 63,0872 | 1,34477 | 60,8387 | 65,3357 |
| 8 | 2 | 90,7678 | 1,34477 | 88,5192 | 93,0163 |
| Total | 14 | 48,5284 | | | |

Table 4 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for AO conversion as a function of C are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 4 shows that there are no significant differences when performing esterification with ethanol or propanol. The same happens when carrying out the reaction with 1-pentanol or 1-hexanol. Table 5 shows the estimated difference between each pair of means. An asterisk has been placed next to 19 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 4.** Multiple Range Tests for OA Conversion by C. Method: 95,0 percent LSD

| Level | Count | Mean | Homogeneous Groups |
|---|---|---|---|
| 2 | 2 | 7,98186 | X |
| 3 | 2 | 8,5601 | X |
| 4 | 2 | 21,5003 | X |
| 7 | 2 | 63,0872 | X |
| 6 | 2 | 73,6466 | X |
| 5 | 2 | 74,1546 | X |
| 8 | 2 | 90,7678 | X |

**Table 5.** Estimated difference between each pair of means

| Contrast | Sig. | Difference | +/- Limits |
|---|---|---|---|
| 2 - 3 | | -0,578246 | 4,49705 |
| 2 - 4 | * | -13,5185 | 4,49705 |
| 2 - 5 | * | -66,1727 | 4,49705 |
| 2 - 6 | * | -65,6647 | 4,49705 |
| 2 - 7 | * | -55,1054 | 4,49705 |

| | | | |
|---|---|---|---|
| 2 - 8 | * | -82,7859 | 4,49705 |
| 3 - 4 | * | -12,9402 | 4,49705 |
| 3 - 5 | * | -65,5945 | 4,49705 |
| 3 - 6 | * | -65,0865 | 4,49705 |
| 3 - 7 | * | -54,5271 | 4,49705 |
| 3 - 8 | * | -82,2077 | 4,49705 |
| 4 - 5 | * | -52,6542 | 4,49705 |
| 4 - 6 | * | -52,1462 | 4,49705 |
| 4 - 7 | * | -41,5869 | 4,49705 |
| 4 - 8 | * | -69,2674 | 4,49705 |
| 5 - 6 | | 0,508002 | 4,49705 |
| 5 - 7 | * | 11,0674 | 4,49705 |
| 5 - 8 | * | -16,6132 | 4,49705 |
| 6 - 7 | * | 10,5594 | 4,49705 |
| 6 - 8 | * | -17,1212 | 4,49705 |
| 7 - 8 | * | -27,6806 | 4,49705 |

* denotes a statistically significant difference.

Figures 1 and 2 present the measured values and the means with the 95% LSD intervals, respectively.

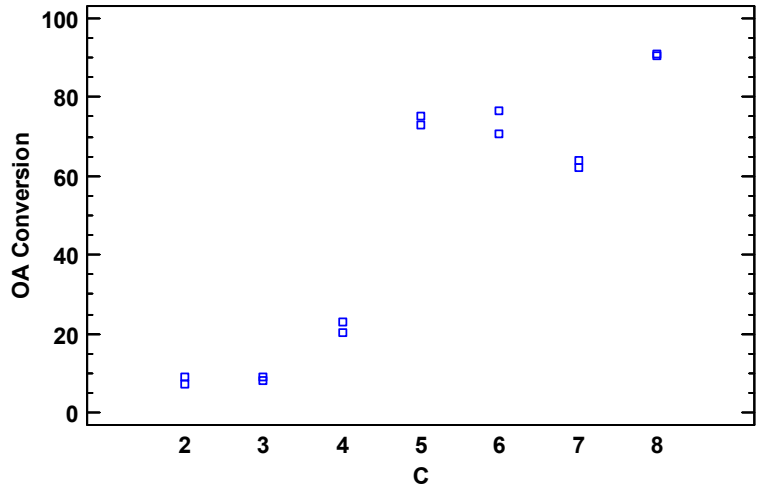


**Figure 1.** Scatter plot by level code.

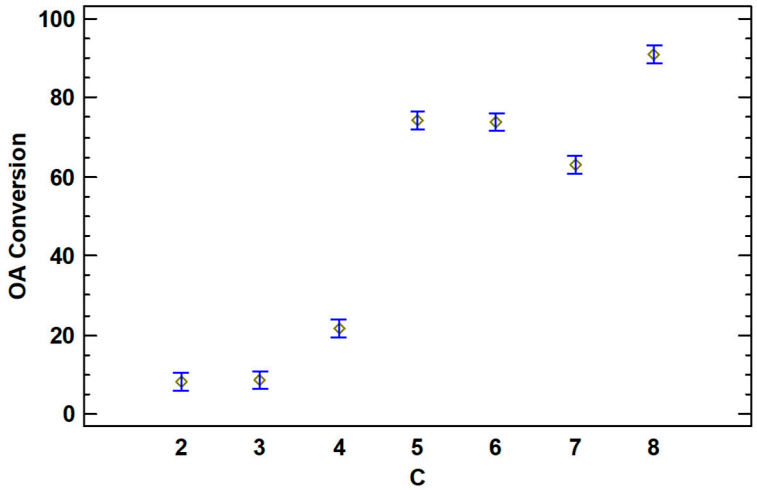


**Figure 2.** Means and 95.0% LSD intervals.

## 2. Esterification of oleic acid (OA) and 1-octanol as a function of temperature

### *One-Way ANOVA*

Dependent variable: OA Conversion
Factor: Temperature

Number of observations: 10
Number of levels: 5

A one-way analysis of variance (ANOVA) for OA Conversion was performed. It allows comparing the mean values of OA Conversion for the 5 different levels of Temperature. The F-test (Table 2) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 9).

Table 1 shows various statistics for OA Conversion for each of the 5 levels of Temperature. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 6.** Summary Statistics for OA Conversion.

| *Temperature* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* | *Minimum* |
|---|---|---|---|---|---|
| 20 | 2 | 43,7186 | 2,38758 | 5,46124% | 42,0303 |
| 30 | 2 | 90,7678 | 0,232178 | 0,255794% | 90,6036 |
| 40 | 2 | 89,4373 | 1,49617 | 1,67288% | 88,3793 |
| 50 | 2 | 50,6416 | 1,34671 | 2,6593% | 49,6893 |
| 60 | 2 | 12,3939 | 0,698231 | 5,63369% | 11,9001 |
| Total | 10 | 57,3918 | 31,2813 | 54,5049% | 11,9001 |

| *Temperature* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|
| 20 | 45,4069 | 3,37655 | | |
| 30 | 90,9319 | 0,32835 | | |
| 40 | 90,4952 | 2,11591 | | |
| 50 | 51,5938 | 1,90454 | | |
| 60 | 12,8876 | 0,987448 | | |
| Total | 90,9319 | 79,0318 | -0,280557 | -0,904183 |

The ANOVA table (Table 7) decomposes the variance of Conversion into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 1068,13, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean OA Conversion from one level of Temperature to another at the 5% significance level.

**Table 7.** ANOVA Table for OA Conversion by Temperature.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 8796,41 | 4 | 2199,1 | 1068,13 | 0,0000 |
| Within groups | 10,2941 | 5 | 2,05883 | | |
| Total (Corr.) | 8806,7 | 9 | | | |

Table 8 shows the mean OA Conversion for each level of Temperature. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at

each level. Table 3 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time

**Table 8.** List of Means for OA Conversion by Temperature with 95,0 percent LSD intervals.

| | | | Stnd. error | | |
|---|---|---|---|---|---|
| *Temperature* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 20 | 2 | 43,7186 | 1,0146 | 41,8744 | 45,5628 |
| 30 | 2 | 90,7678 | 1,0146 | 88,9235 | 92,612 |
| 40 | 2 | 89,4373 | 1,0146 | 87,5931 | 91,2815 |
| 50 | 2 | 50,6416 | 1,0146 | 48,7974 | 52,4858 |
| 60 | 2 | 12,3939 | 1,0146 | 10,5496 | 14,2381 |
| Total | 10 | 57,3918 | | | |

Table 9 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for AO conversion are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 9 shows that all values of the means are statistically different except for those obtained for 30 and 40 ºC, which correspond to the optimum of the biocatalyst activity and the conversion values as a function of temperature are similar. Table 10 shows the estimated difference between each pair of means. An asterisk has been placed next to 9 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 9.** Multiple Range Tests for OA Conversion by Temperature. Method: 95,0 percent LSD

| *Temperature* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 60 | 2 | 12,3939 | X |
| 20 | 2 | 43,7186 | X |
| 50 | 2 | 50,6416 | X |
| 40 | 2 | 89,4373 | X |
| 30 | 2 | 90,7678 | X |

**Table 10.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 20 - 30 | * | -47,0491 | 3,68844 |
| 20 - 40 | * | -45,7187 | 3,68844 |
| 20 - 50 | * | -6,92296 | 3,68844 |
| 20 - 60 | * | 31,3248 | 3,68844 |
| 30 - 40 | | 1,33049 | 3,68844 |
| 30 - 50 | * | 40,1262 | 3,68844 |
| 30 - 60 | * | 78,3739 | 3,68844 |
| 40 - 50 | * | 38,7957 | 3,68844 |
| 40 - 60 | * | 77,0434 | 3,68844 |
| 50 - 60 | * | 38,2477 | 3,68844 |

* denotes a statistically significant difference.

Figures 3 and 4 present the measured values and the means with the 95% LSD intervals, respectively.

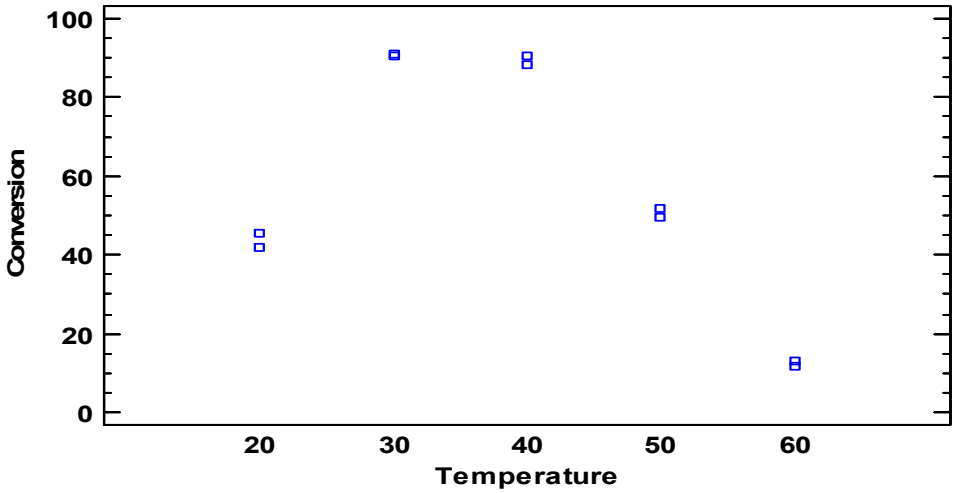


**Figure 3.** Scatter plot by level code.

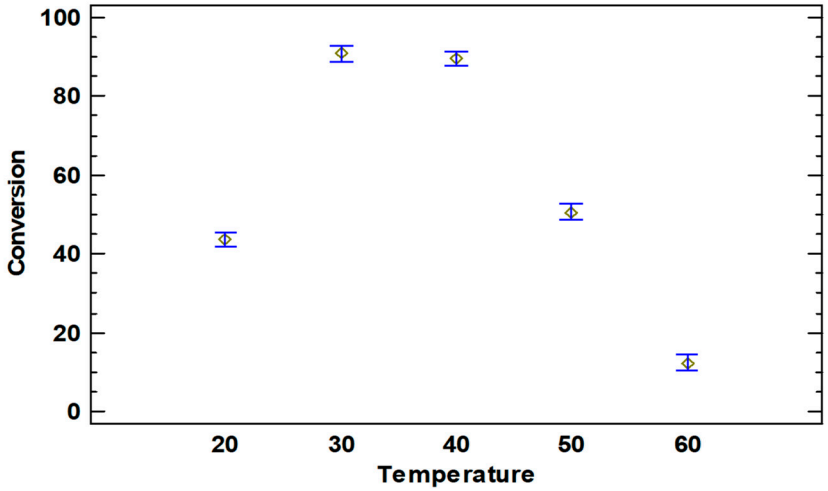


**Figure 4.** Means and 95.0% LSD intervals.

## 3. Esterification of oleic acid (OA) and 1-octanol with different biocatalyst loading

### *One-Way ANOVA*

Dependent variable: OA Conversion
Factor: Biocatalyst loading

Number of observations: 16
Number of levels: 8

A one-way analysis of variance (ANOVA) for OA Conversion was performed. It allows comparing the mean values of OA Conversion for the 8 different levels of Biocatalyst loading. The F-test (Table 12) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 14).

Table 11 shows various statistics for OA Conversion for each of the 8 levels of Biocatalyst loading. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 11.** Summary Statistics for OA Conversion

| *Biocatalyst loading* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* |
|---|---|---|---|---|
| 0 | 2 | 0,0346905 | 0,0213553 | 61,5595% |
| 2,5 | 2 | 25,0311 | 2,13923 | 8,54629% |
| 5 | 2 | 54,2837 | 1,58699 | 2,92351% |
| 7,5 | 2 | 78,788 | 1,719 | 2,18181% |
| 10 | 2 | 90,7678 | 0,232178 | 0,255794% |
| 12,5 | 2 | 92,0838 | 0,378165 | 0,410675% |
| 15 | 2 | 93,4605 | 0,257493 | 0,27551% |
| 17,5 | 2 | 93,4516 | 0,4643 | 0,496835% |
| Total | 16 | 65,9876 | 34,9045 | 52,8955% |

| *Biocatalyst loading* | *Minimum* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|---|
| 0 | 0,01959 | 0,049791 | 0,0302009 | | |
| 2,5 | 23,5184 | 26,5438 | 3,02533 | | |
| 5 | 53,1615 | 55,4058 | 2,24434 | | |
| 7,5 | 77,5725 | 80,0035 | 2,43104 | | |
| 10 | 90,6036 | 90,9319 | 0,32835 | | |
| 12,5 | 91,8164 | 92,3512 | 0,534806 | | |
| 15 | 93,2785 | 93,6426 | 0,36415 | | |
| 17,5 | 93,1233 | 93,7799 | 0,656619 | | |
| Total | 0,01959 | 93,7799 | 93,7603 | -1,64371 | -0,420928 |

The ANOVA table (Table 12) decomposes the variance of Conversion into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 1982,46, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean OA Conversion from one level of biocatalyst loading to another at the 5% significance level.

**Table 12.** ANOVA Table for OA Conversion by Biocatalyst loading.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 18264,3 | 7 | 2609,19 | 1982,46 | 0,0000 |
| Within groups | 10,5291 | 8 | 1,31613 | | |
| Total (Corr.) | 18274,8 | 15 | | | |

Table 13 shows the mean OA Conversion for each level of Biocatalyst loading. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each level. Table 13 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 13.** List of Means for OA Conversion by Biocatalyst loading with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Level* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 0 | 2 | 0,0346905 | 0,811213 | -1,28807 | 1,35745 |
| 2,5 | 2 | 25,0311 | 0,811213 | 23,7083 | 26,3539 |
| 5 | 2 | 54,2837 | 0,811213 | 52,9609 | 55,6064 |
| 7,5 | 2 | 78,788 | 0,811213 | 77,4653 | 80,1108 |
| 10 | 2 | 90,7678 | 0,811213 | 89,445 | 92,0905 |
| 12,5 | 2 | 92,0838 | 0,811213 | 90,761 | 93,4065 |
| 15 | 2 | 93,4605 | 0,811213 | 92,1378 | 94,7833 |
| 17,5 | 2 | 93,4516 | 0,811213 | 92,1289 | 94,7744 |
| Total | 16 | 65,9876 | | | |

Table 14 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for AO conversion as a function of C are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 14 shows statistically significant differences in the AO conversion using less than 10% biocatalyst. A higher dose of biocatalyst does not generate significant changes in the conversion. Table 15 shows the estimated difference between each pair of means. An asterisk has been placed next to 24 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 14.** Multiple Range Tests for OA Conversion by Biocatalyst loading. Method: 95,0 percent LSD

| *Level* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 0 | 2 | 0,0346905 | X |
| 2,5 | 2 | 25,0311 | X |
| 5 | 2 | 54,2837 | X |
| 7,5 | 2 | 78,788 | X |
| 10 | 2 | 90,7678 | X |
| 12,5 | 2 | 92,0838 | XX |
| 17,5 | 2 | 93,4516 | X |
| 15 | 2 | 93,4605 | X |

**Table 15.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 0 - 2,5 | * | -24,9964 | 2,64552 |
| 0 - 5 | * | -54,249 | 2,64552 |
| 0 - 7,5 | * | -78,7533 | 2,64552 |
| 0 - 10 | * | -90,7331 | 2,64552 |
| 0 - 12,5 | * | -92,0491 | 2,64552 |
| 0 - 15 | * | -93,4258 | 2,64552 |
| 0 - 17,5 | * | -93,4169 | 2,64552 |

| | | | |
|---|---|---|---|
| 2,5 - 5 | * | -29,2526 | 2,64552 |
| 2,5 - 7,5 | * | -53,7569 | 2,64552 |
| 2,5 - 10 | * | -65,7367 | 2,64552 |
| 2,5 - 12,5 | * | -67,0527 | 2,64552 |
| 2,5 - 15 | * | -68,4294 | 2,64552 |
| 2,5 - 17,5 | * | -68,4205 | 2,64552 |
| 5 - 7,5 | * | -24,5043 | 2,64552 |
| 5 - 10 | * | -36,4841 | 2,64552 |
| 5 - 12,5 | * | -37,8001 | 2,64552 |
| 5 - 15 | * | -39,1769 | 2,64552 |
| 5 - 17,5 | * | -39,168 | 2,64552 |
| 7,5 - 10 | * | -11,9798 | 2,64552 |
| 7,5 - 12,5 | * | -13,2958 | 2,64552 |
| 7,5 - 15 | * | -14,6725 | 2,64552 |
| 7,5 - 17,5 | * | -14,6636 | 2,64552 |
| 10 - 12,5 | | -1,31601 | 2,64552 |
| 10 - 15 | * | -2,69277 | 2,64552 |
| 10 - 17,5 | * | -2,68386 | 2,64552 |
| 12,5 - 15 | | -1,37675 | 2,64552 |
| 12,5 - 17,5 | | -1,36785 | 2,64552 |
| 15 - 17,5 | | 0,00890497 | 2,64552 |

* denotes a statistically significant difference.

Figures 5 and 6 present the measured values and the means with the 95% LSD intervals, respectively.

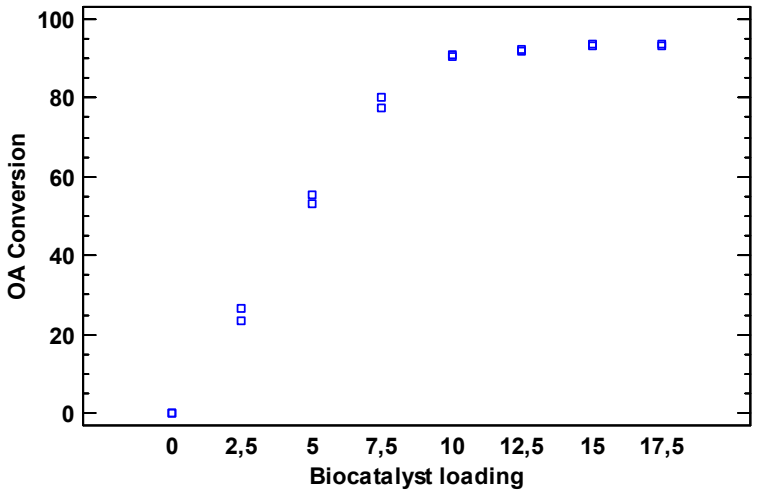


**Figure 5.** Scatter plot by level code.

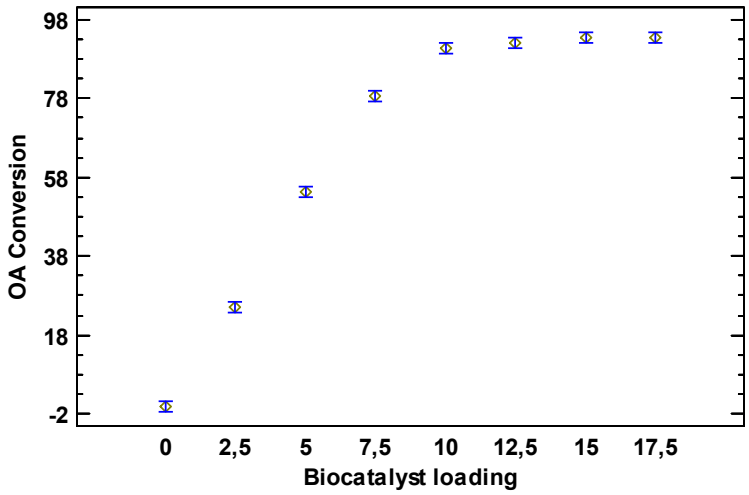


**Figure 6.** Means and 95.0% LSD intervals.

## 4. Esterification of oleic acid (OA) and 1-octanol with different acid/octanol molar ratios

### *One-Way ANOVA*

Dependent variable: OA Conversion
Factor: Biocatalyst loading

Number of observations: 8
Number of levels: 4

A one-way analysis of variance (ANOVA) for OA Conversion was performed. It allows comparing the mean values of OA Conversion for the 4 different levels of acid/octanol molar ratio. The F-test (Table 17) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 19).

Table 16 shows various statistics for OA Conversion for each of the 4 levels of acid/octanol molar ratio. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 16.** Summary Statistics for OA Conversion

| *Molar Ratio* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* | *Minimum* |
|---|---|---|---|---|---|
| 1 | 2 | 78,1935 | 0,0653245 | 0,0835421% | 78,1473 |
| 2 | 2 | 90,7678 | 0,232178 | 0,255794% | 90,6036 |
| 3 | 2 | 61,8067 | 0,631788 | 1,0222% | 61,36 |
| 4 | 2 | 56,1895 | 4,72353 | 8,40643% | 52,8495 |
| Total | 8 | 71,7394 | 14,6928 | 20,4808% | 52,8495 |

| *Molar Ratio* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|
| 1 | 78,2397 | 0,0923827 | | |
| 2 | 90,9319 | 0,32835 | | |
| 3 | 62,2535 | 0,893483 | | |
| 4 | 59,5296 | 6,68008 | | |
| Total | 90,9319 | 38,0825 | 0,262669 | -0,981159 |

The ANOVA table (Table 17) decomposes the variance of Conversion into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 87,16, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean OA Conversion from one level of molar ratio to another at the 5% significance level.

**Table 17.** ANOVA Table for OA Conversion by molar ratio.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 1488,38 | 3 | 496,127 | 87,16 | 0,0004 |
| Within groups | 22,7691 | 4 | 5,69227 | | |
| Total (Corr.) | 1511,15 | 7 | | | |

Table 18 shows the mean OA Conversion for each level of molar ratio. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each level. Table 18 also displays an interval around each mean. The intervals currently displayed

are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 18.** List of Means for OA Conversion by Biocatalyst loading with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Molar Ratio* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 1 | 2 | 78,1935 | 1,68705 | 74,8814 | 81,5056 |
| 2 | 2 | 90,7678 | 1,68705 | 87,4557 | 94,0799 |
| 3 | 2 | 61,8067 | 1,68705 | 58,4946 | 65,1188 |
| 4 | 2 | 56,1895 | 1,68705 | 52,8774 | 59,5016 |
| Total | 8 | 71,7394 | | | |

Table 19 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for AO conversion as a function of C are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 19 shows means with significant differences for molar ratios 1:1, 1:2 and, 1:3. However, when carrying out the reaction with molar ratios 1:3 and 1:4 there is no significant conversion difference. Table 20 shows the estimated difference between each pair of means. An asterisk has been placed next to 5 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 19.** Multiple Range Tests for OA Conversion by acid/octanol molar ratio. Method: 95,0 percent LSD

| *Molar Ratio* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 4 | 2 | 56,1895 | X |
| 3 | 2 | 61,8067 | X |
| 1 | 2 | 78,1935 | X |
| 2 | 2 | 90,7678 | X |

**Table 20.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 1 - 2 | * | -12,5743 | 6,6242 |
| 1 - 3 | * | 16,3868 | 6,6242 |
| 1 - 4 | * | 22,004 | 6,6242 |
| 2 - 3 | * | 28,9611 | 6,6242 |
| 2 - 4 | * | 34,5782 | 6,6242 |
| 3 - 4 | | 5,6172 | 6,6242 |

* denotes a statistically significant difference.

Figures 7 and 8 present the measured values and the means with the 95% LSD intervals, respectively.

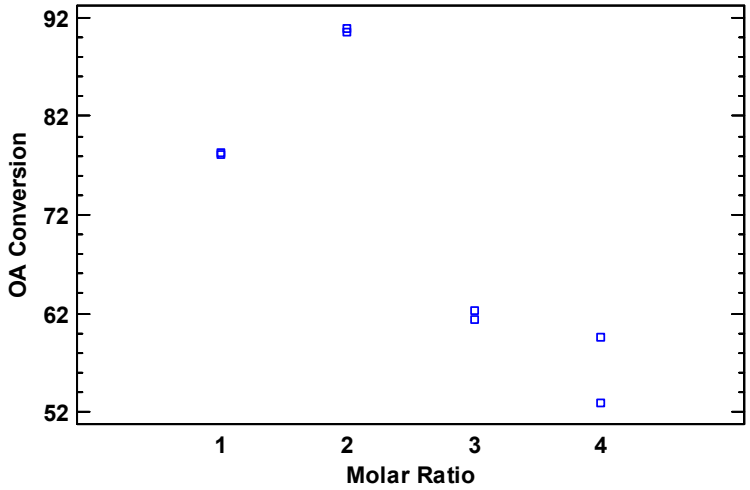


**Figure 7.** Scatter plot by level code.

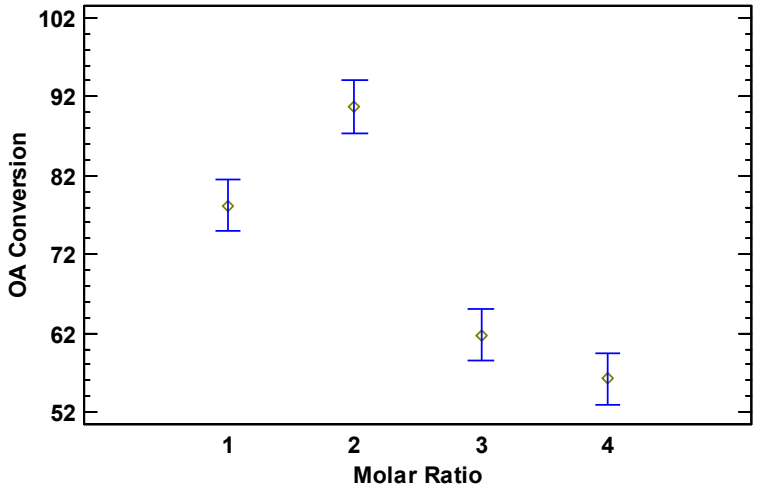


**Figure 8.** Means and 95.0% LSD intervals.

## 5. Esterification of oleic acid (OA) and 1-octanol as a function of time

### *One-Way ANOVA*

Dependent variable: OA Conversion
Factor: Time

Number of observations: 12
Number of levels: 6

A one-way analysis of variance (ANOVA) for OA Conversion was performed. It allows comparing the mean values of OA Conversion for the 6 different levels of time. The F-test (Table 22) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 24).

Table 21 shows various statistics for OA Conversion for each of the 6 levels of time. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 21.** Summary Statistics for OA Conversion

| *Time* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* | *Minimum* |
|---|---|---|---|---|---|
| 0 | 2 | 0,0346905 | 0,0213553 | 61,5595% | 0,01959 |
| 1 | 2 | 28,9785 | 2,97967 | 10,2823% | 26,8716 |
| 2 | 2 | 46,1726 | 2,19907 | 4,7627% | 44,6177 |
| 3 | 2 | 67,1937 | 1,08709 | 1,61784% | 66,425 |
| 4 | 2 | 88,5539 | 0,632079 | 0,713779% | 88,1069 |
| 5 | 2 | 90,7678 | 0,232178 | 0,255794% | 90,6036 |
| Total | 12 | 53,6169 | 33,9151 | 63,2546% | 0,01959 |

| *Time* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|
| 0 | 0,049791 | 0,0302009 | | |
| 1 | 31,0855 | 4,21389 | | |
| 2 | 47,7276 | 3,10995 | | |
| 3 | 67,9624 | 1,53738 | | |
| 4 | 89,0008 | 0,893894 | | |
| 5 | 90,9319 | 0,32835 | | |
| Total | 90,9319 | 90,9123 | -0,578337 | -0,820246 |

The ANOVA table (Table 22) decomposes the variance of Conversion into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 987,93, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean OA Conversion from one level of time to another at the 5% significance level.

**Table 22.** ANOVA Table for OA Conversion by Time.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 12637,3 | 5 | 2527,45 | 987,93 | 0,0000 |
| Within groups | 15,35 | 6 | 2,55833 | | |
| Total (Corr.) | 12652,6 | 11 | | | |

Table 23 shows the mean OA Conversion for each level of time. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each

level. Table 23 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 23.** List of Means for OA Conversion by Time with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Molar Ratio* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 1 | 2 | 78,1935 | 1,68705 | 74,8814 | 81,5056 |
| 2 | 2 | 90,7678 | 1,68705 | 87,4557 | 94,0799 |
| 3 | 2 | 61,8067 | 1,68705 | 58,4946 | 65,1188 |
| 4 | 2 | 56,1895 | 1,68705 | 52,8774 | 59,5016 |
| Total | 8 | 71,7394 | | | |

Table 24 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for AO conversion as a function of C are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 25 shows that for all time values the conversion of oleic acid is significantly different, except for time 4 and 5, where the maximum conversion occurs and the system seems to reach equilibrium. Table 25 shows the estimated difference between each pair of means. An asterisk has been placed next to 14 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 24.** Multiple Range Tests for OA Conversion by Time. Method: 95,0 percent LSD

| *Time* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 0 | 2 | 0,0346905 | X |
| 1 | 2 | 28,9785 | X |
| 2 | 2 | 46,1726 | X |
| 3 | 2 | 67,1937 | X |
| 4 | 2 | 88,5539 | X |
| 5 | 2 | 90,7678 | X |

**Table 25.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 0 - 1 | * | -28,9439 | 3,91379 |
| 0 - 2 | * | -46,1379 | 3,91379 |
| 0 - 3 | * | -67,159 | 3,91379 |
| 0 - 4 | * | -88,5192 | 3,91379 |
| 0 - 5 | * | -90,7331 | 3,91379 |
| 1 - 2 | * | -17,1941 | 3,91379 |
| 1 - 3 | * | -38,2152 | 3,91379 |
| 1 - 4 | * | -59,5754 | 3,91379 |
| 1 - 5 | * | -61,7892 | 3,91379 |
| 2 - 3 | * | -21,0211 | 3,91379 |
| 2 - 4 | * | -42,3813 | 3,91379 |
| 2 - 5 | * | -44,5951 | 3,91379 |
| 3 - 4 | * | -21,3602 | 3,91379 |
| 3 - 5 | * | -23,574 | 3,91379 |
| 4 - 5 | | -2,21387 | 3,91379 |

* denotes a statistically significant difference.

Figures 9 and 10 present the measured values and the means with the 95% LSD intervals, respectively.

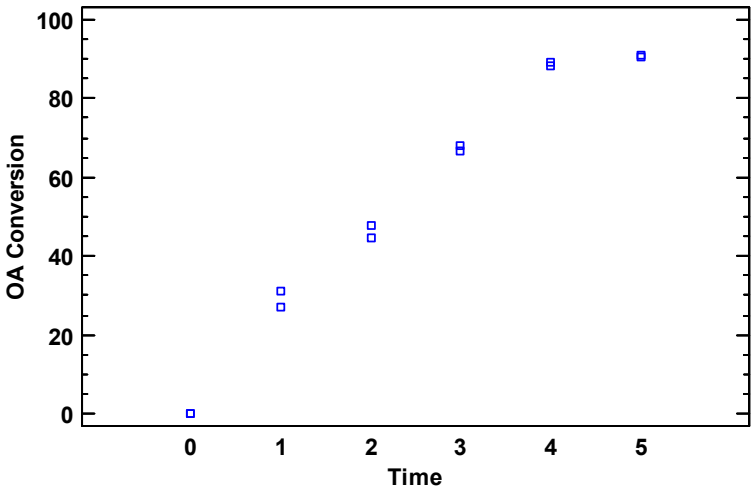


**Figure 9.** Scatter plot by level code.

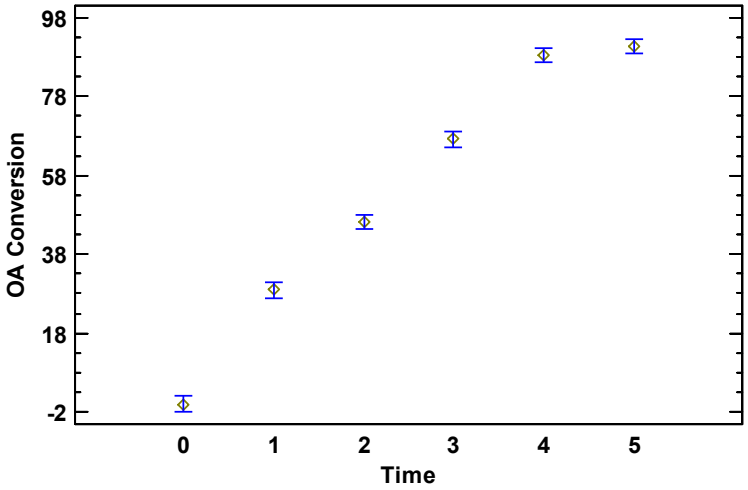


**Figure 10.** Means and 95.0% LSD intervals.

## 6. Yield to free fatty acids (FFA) in the hydrolysis of soybean oil with different oil/water molar ratios.

### *One-Way ANOVA*

Dependent variable: Yield to free fatty acids
Factor: oil/water molar ratio

Number of observations: 8
Number of levels: 4

A one-way analysis of variance (ANOVA) for Yield to free fatty acids was performed. It allows comparing the mean values of Yield to FFA for the 4 different levels of molar ratio. The F-test (Table 27) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 29).

Table 26 shows various statistics for Yield to FFA for each of the 4 levels of molar ratio. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 26.** Summary Statistics for Yield to free fatty acids

| *oil/ water molar ratio* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* |
|---|---|---|---|---|
| 3 | 2 | 60,9168 | 0,950519 | 1,56036% |
| 6 | 2 | 65,3876 | 0,54213 | 0,829103% |
| 9 | 2 | 68,4205 | 0,00321573 | 0,00469995% |
| 12 | 2 | 68,0688 | 1,69538 | 2,49069% |
| Total | 8 | 65,6984 | 3,29609 | 5,017% |

| *oil/ water molar ratio* | *Minimum* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|---|
| 3 | 60,2447 | 61,5889 | 1,34424 | | |
| 6 | 65,0043 | 65,7709 | 0,766688 | | |
| 9 | 68,4182 | 68,4227 | 0,00454773 | | |
| 12 | 66,8699 | 69,2676 | 2,39764 | | |
| Total | 60,2447 | 69,2676 | 9,02292 | -0,887733 | -0,40716 |

The ANOVA table (Table 27) decomposes the variance of Yield to FFA into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 23,57, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean Yield from one level of molar ratio to another at the 5% significance level.

**Table 27.** ANOVA Table for Yield to free fatty acids by molar ratio.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 71,9777 | 3 | 23,9926 | 23,57 | 0,0053 |
| Within groups | 4,07173 | 4 | 1,01793 | | |
| Total (Corr.) | 76,0494 | 7 | | | |

Table 28 shows the mean Yield to FFA for each level of molar ratio. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each level. Table 28 also displays an interval around each mean. The intervals currently displayed

are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 28.** List of Means for Yield to free fatty acids by oil/water molar ratio with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Level* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 3 | 2 | 60,9168 | 0,713419 | 59,5162 | 62,3174 |
| 6 | 2 | 65,3876 | 0,713419 | 63,987 | 66,7882 |
| 9 | 2 | 68,4205 | 0,713419 | 67,0199 | 69,8211 |
| 12 | 2 | 68,0688 | 0,713419 | 66,6681 | 69,4694 |
| Total | 8 | 65,6984 | | | |

Table 29 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for Yield as a function of the oil/water molar ratio are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 30 shows the estimated difference between each pair of means. An asterisk has been placed next to 4 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 29.** Multiple Range Tests for OA Conversion by Time. Method: 95,0 percent LSD

| *Level* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 3 | 2 | 60,9168 | X |
| 6 | 2 | 65,3876 | X |
| 12 | 2 | 68,0688 | XX |
| 9 | 2 | 68,4205 | X |

**Table 30.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 3 - 6 | * | -4,47083 | 2,80124 |
| 3 - 9 | * | -7,5037 | 2,80124 |
| 3 - 12 | * | -7,15199 | 2,80124 |
| 6 - 9 | * | -3,03286 | 2,80124 |
| 6 - 12 | | -2,68116 | 2,80124 |
| 9 - 12 | | 0,351708 | 2,80124 |

* denotes a statistically significant difference.

Figures 11 and 12 present the measured values and the means with the 95% LSD intervals, respectively.

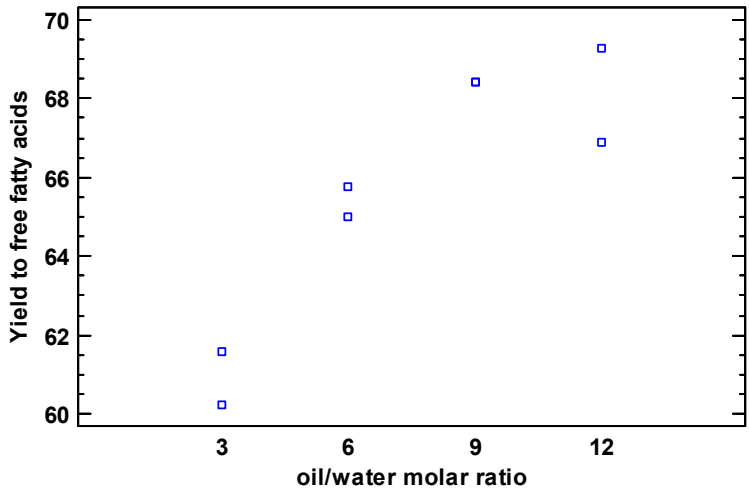


**Figure 11.** Scatter plot by level code.

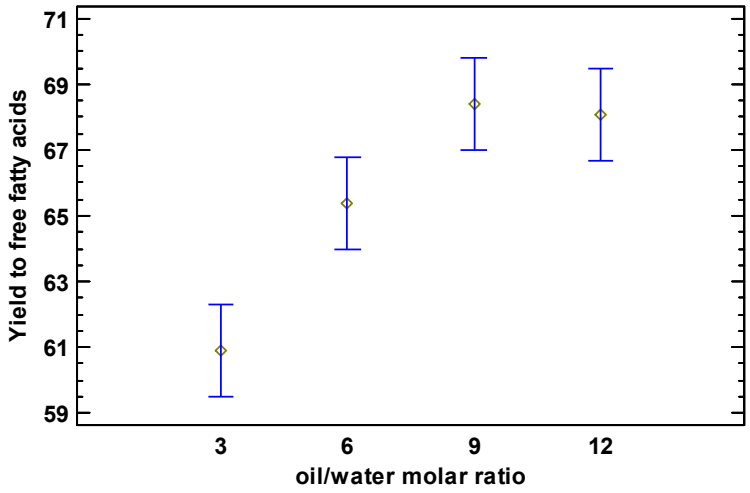


**Figure 12.** Means and 95.0% LSD intervals.

## 7. Yield to free fatty acids (FFA) in the hydrolysis of soybean oil as a function of temperature

### *One-Way ANOVA*

Dependent variable: Yield to free fatty acids
Factor: oil/water molar ratio

Number of observations: 10
Number of levels: 5

A one-way analysis of variance (ANOVA) for Yield to free fatty acids was performed. It allows comparing the mean values of Yield to FFA for the 5 different levels of temperature. The F-test (Table 32) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 34).

Table 31 shows various statistics for Yield to FFA for each of the 5 levels of temperature. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 31.** Summary Statistics for Yield to free fatty acids

| *Temperature* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* | *Minimum* |
|---|---|---|---|---|---|
| 20 | 2 | 59,913 | 3,02048 | 5,04145% | 57,7772 |
| 30 | 2 | 68,0688 | 1,69538 | 2,49069% | 66,8699 |
| 40 | 2 | 55,5478 | 1,824 | 3,28365% | 54,258 |
| 50 | 2 | 50,9186 | 1,39798 | 2,74552% | 49,9301 |
| 60 | 2 | 15,5916 | 2,09294 | 13,4236% | 14,1116 |
| Total | 10 | 50,0079 | 19,1551 | 38,3042% | 14,1116 |

| *Temperature* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|
| 20 | 62,0488 | 4,27161 | | |
| 30 | 69,2676 | 2,39764 | | |
| 40 | 56,8375 | 2,57952 | | |
| 50 | 51,9071 | 1,97704 | | |
| 60 | 17,0715 | 2,95987 | | |
| Total | 69,2676 | 55,1559 | -1,7202 | 0,424939 |

The ANOVA table (Table 32) decomposes the variance of Yield to FFA into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 189,33, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean Yield from one level of temperature to another at the 5% significance level.

**Table 32.** ANOVA Table for Yield to free fatty acids by temperature.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 3280,62 | 4 | 820,154 | 189,33 | 0,0000 |
| Within groups | 21,6594 | 5 | 4,33187 | | |
| Total (Corr.) | 3302,28 | 9 | | | |

Table 33 shows the mean Yield to FFA for each level of temperature. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed

by dividing the pooled standard deviation by the square root of the number of observations at each level. Table 33 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 33.** List of Means for Yield to free fatty acids by temperature with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Temperature* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 20 | 2 | 59,913 | 1,47171 | 57,2379 | 62,5881 |
| 30 | 2 | 68,0688 | 1,47171 | 65,3937 | 70,7439 |
| 40 | 2 | 55,5478 | 1,47171 | 52,8727 | 58,2229 |
| 50 | 2 | 50,9186 | 1,47171 | 48,2435 | 53,5937 |
| 60 | 2 | 15,5916 | 1,47171 | 12,9165 | 18,2667 |
| Total | 10 | 50,0079 | | | |

Table 34 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for Yield as a function of the temperature are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 35 shows the estimated difference between each pair of means. An asterisk has been placed next to 8 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 34.** Multiple Range Tests for OA Conversion by temperature. Method: 95,0 percent LSD

| *Temperature* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 60 | 2 | 15,5916 | X |
| 50 | 2 | 50,9186 | X |
| 40 | 2 | 55,5478 | XX |
| 20 | 2 | 59,913 | X |
| 30 | 2 | 68,0688 | X |

**Table 30.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 20 - 30 | * | -8,15578 | 5,35021 |
| 20 - 40 | | 4,36522 | 5,35021 |
| 20 - 50 | * | 8,99435 | 5,35021 |
| 20 - 60 | * | 44,3214 | 5,35021 |
| 30 - 40 | * | 12,521 | 5,35021 |
| 30 - 50 | * | 17,1501 | 5,35021 |
| 30 - 60 | * | 52,4772 | 5,35021 |
| 40 - 50 | | 4,62913 | 5,35021 |
| 40 - 60 | * | 39,9562 | 5,35021 |
| 50 - 60 | * | 35,3271 | 5,35021 |

* denotes a statistically significant difference.

Figures 13 and 14 present the measured values and the means with the 95% LSD intervals, respectively.

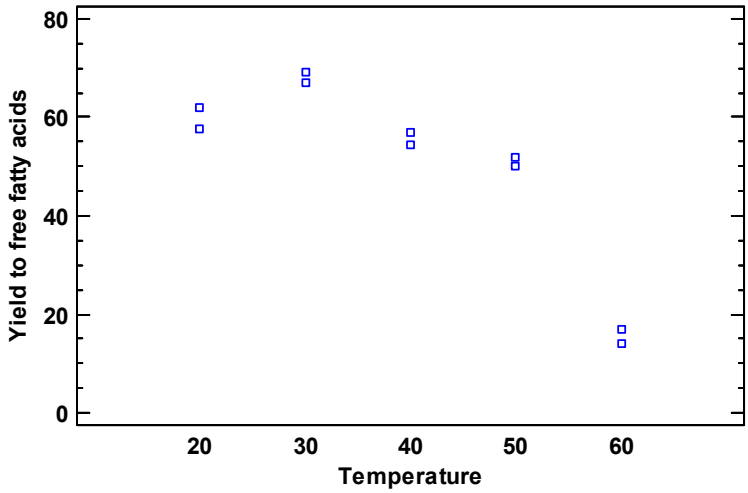


**Figure 11.** Scatter plot by level code.

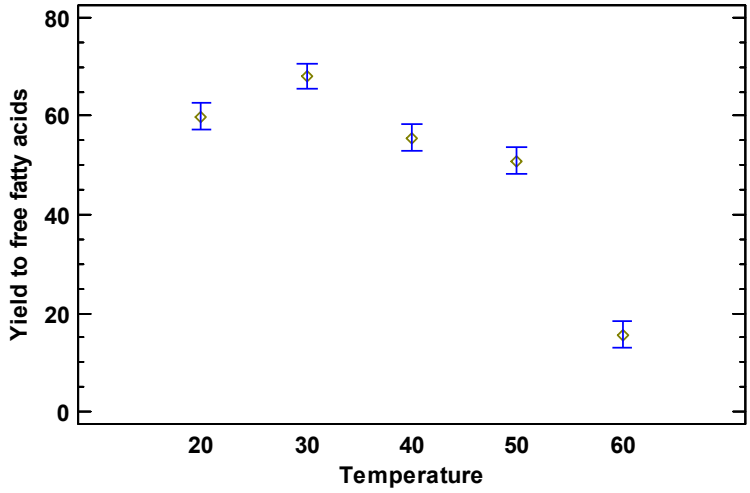


**Figure 12.** Means and 95.0% LSD intervals.

## 8. Yield to free fatty acids (FFA) in the hydrolysis of soybean oil with different biocatalyst loading

### *One-Way ANOVA*

Dependent variable: Yield to free fatty acids
Factor: biocatalyst loading

Number of observations: 14
Number of levels: 7

A one-way analysis of variance (ANOVA) for Yield to free fatty acids was performed. It allows comparing the mean values of Yield to FFA for the 7 different levels of biocatalyst loading. The F-test (Table 37) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 39).

Table 36 shows various statistics for Yield to FFA for each of the 7 levels of biocatalyst loading. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 36.** Summary Statistics for Yield to free fatty acids

| *Biocatalyst loading* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* |
|---|---|---|---|---|
| 0 | 2 | 0 | 0 | % |
| 3 | 2 | 29,9375 | 1,49521 | 4,99444% |
| 5 | 2 | 45,7392 | 0,846101 | 1,84984% |
| 7,5 | 2 | 58,6558 | 0,791416 | 1,34926% |
| 10 | 2 | 68,0688 | 1,69538 | 2,49069% |
| 12,5 | 2 | 68,3433 | 0,269936 | 0,394971% |
| 15 | 2 | 69,6113 | 0,429285 | 0,616689% |
| Total | 14 | 48,6223 | 24,9097 | 51,2311% |

| *Biocatalyst loading* | *Minimum* | *Maximum* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | | |
| 3 | 28,8803 | 30,9948 | 2,11455 | | |
| 5 | 45,1409 | 46,3375 | 1,19657 | | |
| 7,5 | 58,0962 | 59,2154 | 1,11923 | | |
| 10 | 66,8699 | 69,2676 | 2,39764 | | |
| 12,5 | 68,1524 | 68,5341 | 0,381747 | | |
| 15 | 69,3077 | 69,9148 | 0,607101 | | |
| Total | 0 | 69,9148 | 69,9148 | -1,70609 | 0,0843484 |

The ANOVA table (Table 37) decomposes the variance of Yield to FFA into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 1401,47, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean Yield from one level of biocatalyst loading to another at the 5% significance level.

**Table 37.** ANOVA Table for Yield to free fatty acids by temperature.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 8059,7 | 6 | 1343,28 | 1401,47 | 0,0000 |
| Within groups | 6,70937 | 7 | 0,958481 | | |
| Total (Corr.) | 8066,41 | 13 | | | |

Table 38 shows the mean Yield to FFA for each level of temperature. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each level. Table 38 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 38.** List of Means for Yield to free fatty acids by biocatalyst loading with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Level* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 0 | 2 | 0 | 0,692272 | -1,15751 | 1,15751 |
| 3 | 2 | 29,9375 | 0,692272 | 28,78 | 31,0951 |
| 5 | 2 | 45,7392 | 0,692272 | 44,5817 | 46,8967 |
| 7,5 | 2 | 58,6558 | 0,692272 | 57,4983 | 59,8133 |
| 10 | 2 | 68,0688 | 0,692272 | 66,9113 | 69,2263 |
| 12,5 | 2 | 68,3433 | 0,692272 | 67,1857 | 69,5008 |
| 15 | 2 | 69,6113 | 0,692272 | 68,4538 | 70,7688 |
| Total | 14 | 48,6223 | | | |

Table 39 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for Yield as a function of the biocatalyst loading are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 40 shows the estimated difference between each pair of means. An asterisk has been placed next to 18 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 39.** Multiple Range Tests for OA Conversion by biocatalyst loading. Method: 95,0 percent LSD

| *Level* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 0 | 2 | 0 | X |
| 3 | 2 | 29,9375 | X |
| 5 | 2 | 45,7392 | X |
| 7,5 | 2 | 58,6558 | X |
| 10 | 2 | 68,0688 | X |
| 12,5 | 2 | 68,3433 | X |
| 15 | 2 | 69,6113 | X |

**Table 40.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 0 - 3 | * | -29,9375 | 2,31502 |
| 0 - 5 | * | -45,7392 | 2,31502 |
| 0 - 7,5 | * | -58,6558 | 2,31502 |
| 0 - 10 | * | -68,0688 | 2,31502 |
| 0 - 12,5 | * | -68,3433 | 2,31502 |
| 0 - 15 | * | -69,6113 | 2,31502 |
| 3 - 5 | * | -15,8017 | 2,31502 |
| 3 - 7,5 | * | -28,7182 | 2,31502 |
| 3 - 10 | * | -38,1312 | 2,31502 |
| 3 - 12,5 | * | -38,4057 | 2,31502 |
| 3 - 15 | * | -39,6737 | 2,31502 |
| 5 - 7,5 | * | -12,9166 | 2,31502 |
| 5 - 10 | * | -22,3296 | 2,31502 |

| | | | |
|---|---|---|---|
| 5 - 12,5 | * | -22,6041 | 2,31502 |
| 5 - 15 | * | -23,8721 | 2,31502 |
| 7,5 - 10 | * | -9,41298 | 2,31502 |
| 7,5 - 12,5 | * | -9,68748 | 2,31502 |
| 7,5 - 15 | * | -10,9555 | 2,31502 |
| 10 - 12,5 | | -0,274497 | 2,31502 |
| 10 - 15 | | -1,54251 | 2,31502 |
| 12,5 - 15 | | -1,26801 | 2,31502 |

* denotes a statistically significant difference.

Figures 15 and 16 present the measured values and the means with the 95% LSD intervals, respectively.

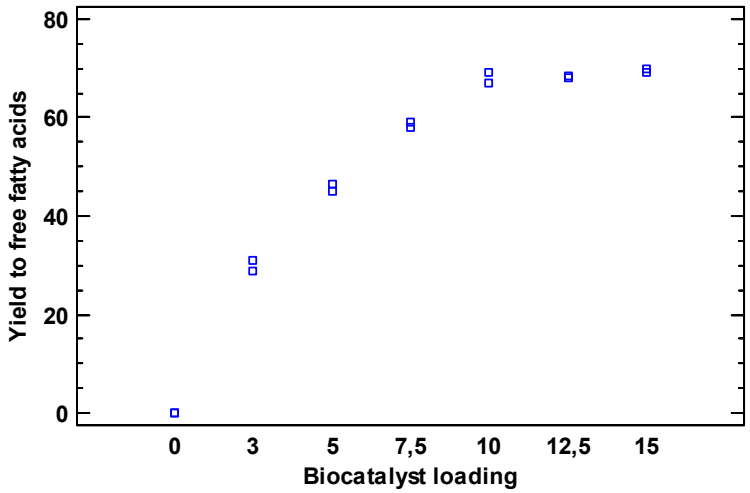


**Figure 15.** Scatter plot by level code.

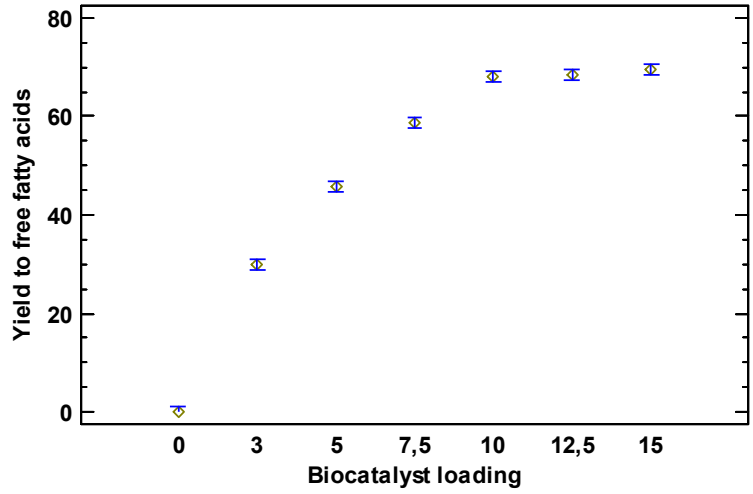


**Figure 16.** Means and 95.0% LSD intervals.

## 9. Yield to free fatty acids (FFA) in the hydrolysis of soybean as a function of time

### *One-Way ANOVA*

Dependent variable: Yield to free fatty acids
Factor: time

Number of observations: 12
Number of levels: 6

A one-way analysis of variance (ANOVA) for Yield to free fatty acids was performed. It allows comparing the mean values of Yield to FFA for the 6 different levels of time. The F-test (Table 42) analyses whether there are any significant differences amongst the means. The Multiple Range Tests indicates which means are significantly different from which others (Table 44).

Table 41 shows various statistics for Yield to FFA for each of the 6 levels of time. The one-way analysis of variance is primarily intended to compare the means of the different levels, listed here under the Average column.

**Table 41.** Summary Statistics for Yield to free fatty acids

| *Time* | *Count* | *Average* | *Standard deviation* | *Coeff. of variation* | *Minimum* | *Maximum* |
|---|---|---|---|---|---|---|
| 0 | 2 | 0 | 0 | % | 0 | 0 |
| 1 | 2 | 31,6389 | 0,260736 | 0,824101% | 31,4545 | 31,8233 |
| 2 | 2 | 41,474 | 1,24259 | 2,99606% | 40,5954 | 42,3527 |
| 3 | 2 | 48,195 | 0,236718 | 0,491167% | 48,0276 | 48,3624 |
| 4 | 2 | 54,3748 | 0,0941068 | 0,173071% | 54,3082 | 54,4413 |
| 5 | 2 | 68,0688 | 1,69538 | 2,49069% | 66,8699 | 69,2676 |
| Total | 12 | 40,6252 | 22,2941 | 54,8776% | 0 | 69,2676 |

| *Time* | *Range* | *Stnd. skewness* | *Stnd. kurtosis* |
|---|---|---|---|
| 0 | 0 | | |
| 1 | 0,368737 | | |
| 2 | 1,75728 | | |
| 3 | 0,33477 | | |
| 4 | 0,133087 | | |
| 5 | 2,39764 | | |
| Total | 69,2676 | -1,22386 | 0,163775 |

The ANOVA table (Table 42) decomposes the variance of Yield to FFA into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 1440,34, is a ratio of the between-group estimate to the within-group estimate. Since the P-value of the F-test is less than 0,05, there is a statistically significant difference between the mean Yield from one level of time to another at the 5% significance level.

**Table 42.** ANOVA Table for Yield to free fatty acids by temperature.

| *Source* | *Sum of Squares* | *Df* | *Mean Square* | *F-Ratio* | *P-Value* |
|---|---|---|---|---|---|
| Between groups | 5462,77 | 5 | 1092,55 | 1440,34 | 0,0000 |
| Within groups | 4,55123 | 6 | 0,758538 | | |
| Total (Corr.) | 5467,32 | 11 | | | |

Table 43 shows the mean Yield to FFA for each level of time. It also shows the standard error of each mean, which is a measure of its sampling variability. The standard error is formed by dividing the pooled standard deviation by the square root of the number of observations at each

level. Table 43 also displays an interval around each mean. The intervals currently displayed are based on Fisher's least significant difference (LSD) procedure. They are constructed in such a way that if two means are the same, their intervals will overlap 95,0% of the time.

**Table 43.** List of Means for Yield to free fatty acids by biocatalyst loading with 95,0 percent LSD intervals

| | | | *Stnd. error* | | |
|---|---|---|---|---|---|
| *Time* | *Count* | *Mean* | *(pooled s)* | *Lower limit* | *Upper limit* |
| 0 | 2 | 0 | 0,615848 | -1,06556 | 1,06556 |
| 1 | 2 | 31,6389 | 0,615848 | 30,5733 | 32,7045 |
| 2 | 2 | 41,474 | 0,615848 | 40,4085 | 42,5396 |
| 3 | 2 | 48,195 | 0,615848 | 47,1295 | 49,2606 |
| 4 | 2 | 54,3748 | 0,615848 | 53,3092 | 55,4404 |
| 5 | 2 | 68,0688 | 0,615848 | 67,0032 | 69,1343 |
| Total | 12 | 40,6252 | | | |

Table 44 applies a multiple comparison procedure to determine which means are significantly different from which others. The X's located in different columns indicate that the means for Yield as a function of the time are statistically different. The X's located in the same column indicate that there are no statistically significant difference between the means. Table 45 shows the estimated difference between each pair of means. An asterisk has been placed next to 15 pairs, indicating that these pairs show statistically significant differences at the 95,0% confidence level. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure.

**Table 44.** Multiple Range Tests for OA Conversion by biocatalyst loading. Method: 95,0 percent LSD

| *Time* | *Count* | *Mean* | *Homogeneous Groups* |
|---|---|---|---|
| 0 | 2 | 0 | X |
| 1 | 2 | 31,6389 | X |
| 2 | 2 | 41,474 | X |
| 3 | 2 | 48,195 | X |
| 4 | 2 | 54,3748 | X |
| 5 | 2 | 68,0688 | X |

**Table 45.** Estimated difference between each pair of means

| *Contrast* | *Sig.* | *Difference* | *+/- Limits* |
|---|---|---|---|
| 0 - 1 | * | -31,6389 | 2,13112 |
| 0 - 2 | * | -41,474 | 2,13112 |
| 0 - 3 | * | -48,195 | 2,13112 |
| 0 - 4 | * | -54,3748 | 2,13112 |
| 0 - 5 | * | -68,0688 | 2,13112 |
| 1 - 2 | * | -9,83511 | 2,13112 |
| 1 - 3 | * | -16,5561 | 2,13112 |
| 1 - 4 | * | -22,7359 | 2,13112 |
| 1 - 5 | * | -36,4299 | 2,13112 |
| 2 - 3 | * | -6,721 | 2,13112 |
| 2 - 4 | * | -12,9008 | 2,13112 |
| 2 - 5 | * | -26,5947 | 2,13112 |
| 3 - 4 | * | -6,17978 | 2,13112 |
| 3 - 5 | * | -19,8737 | 2,13112 |
| 4 - 5 | * | -13,694 | 2,13112 |

* denotes a statistically significant difference.

Figures 17 and 18 present the measured values and the means with the 95% LSD intervals, respectively.

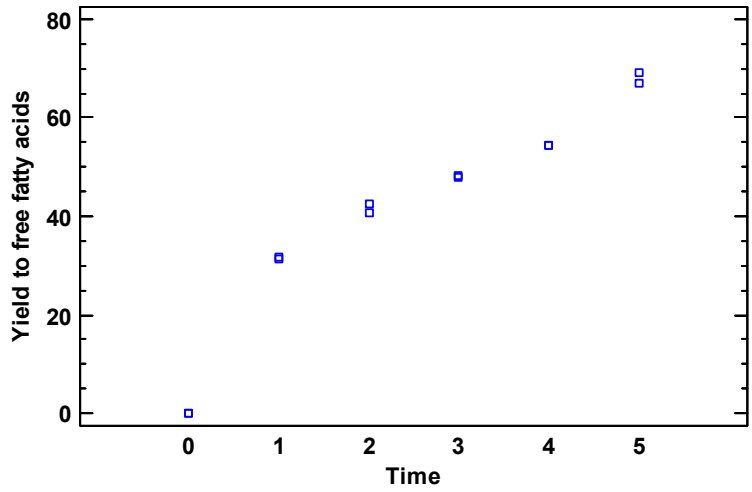


**Figure 13.** Scatter plot by level code.

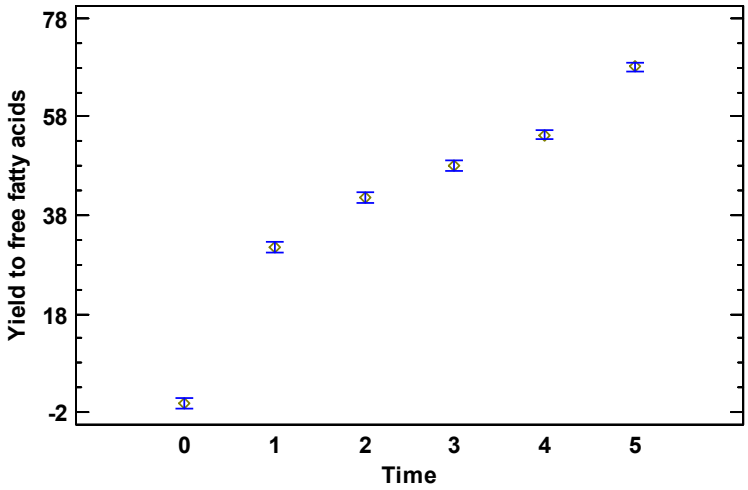


**Figure 12.** Means and 95.0% LSD intervals.