Chemometrics Didactic Experiment for the planning of experiments: Efficiency of Natura perfume brand

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Resumen

El objetivo del presente estudio es describir un experimento práctico que puede emplearse para enseñar los conceptos importantes relacionados con el curso de Diseño de Experimentos utilizando el lenguaje R y SPSS. Se seleccionó el modelo del diseño de experimentos de bloques completamente al azar con el fin de determinar si existe o no diferencias significativas en las duraciones de las fragancias de cuatro tipos de perfumes con cuatro catadores, de la marca de perfume NATURA. Luego para que los resultados sean confiables, se verificó el cumplimiento de las pruebas de normalidad, homocedasticidad de varianzas e independencia de Residuos. Tras haber realizado el experimento, en el ANOVA se concluyó que sí existe diferencia significativa en las duraciones de las fragancias de los tipos de perfume al 95% de confianza y también la evidencia que no existe diferencia significativa en la evaluación sensorial de los catadores. Luego se procedió a realizar un análisis Post Hoc: DMS, Tukey y Bonferroni con $\alpha=0.05$, el cual ayudó a determinar los pares de medias distintos entre sí, detectando el perfume ESSENCIAL de mayor duración de fragancia. El estudio aporta la importancia de saber que la subjetividad de los catadores no influye en la duración de las fragancias y la mejora de la calidad del perfume o en la elaboración de nuevas fragancias en el mercado a partir de componentes químicos básicos como etanol desnaturalizado (C_2H_6O), esencia o fragancia, fijador, propilenglicol ($C_3H_8O_2$) y agua destilada (H_2O) incluyendo los componentes exclusivos del perfume ESSENCIAL que tienen una mayor duración de fragancia más otros nuevos componentes.

Palabras clave: Diseño de Bloques Completos al Azar, Análisis Post Hoc, Análisis de Varianza, Eficiencia de los perfumes.

Abstract

The purpose of this study is to describe a model of a practical experiment that can be applied in the classroom about the importance of concepts associated with the Design of Experiments course using the R language and SPSS. The completely randomized block design of the experiment model was selected in order to determine whether or not there are significant differences in the fragrance durations of four types of perfumes with four tasters, of the NATURA perfume brand. Then, in order to ensure the accuracy of the results, the normality, homoscedasticity of variances and independence of residuals tests were verified. After performing the experiment, the ANOVA analysis indicated that there is a significant difference in the fragrance durations of the perfume types at 95% confidence and also evidence that there is no significant difference in the sensory evaluation of the tasters. We then proceeded to perform a Post Hoc analysis: DMS, Tukey and Bonferroni with

α=0.05, which helped to determine the pairs of means different from each other, detecting the type of perfume with the longest fragrance duration. The study brings the importance of understanding that the subjectivity of the tasters have no influence on the duration of the fragrances and the improvement of the perfume quality or the development of new fragrances in the market from basic chemical components such as denatured ethanol (C_2H_6O) , essence or fragrance, fixative, propylene glycol ($C_3H_8O_2$) and distilled water (H_2O) including the exclusive perfume components that have a longer duration of ESSENCIAL fragrance and other new components.

Keywords: Randomized Complete Block Design, Post Hoc Analysis, Analysis of Variance, Perfume Efficiency.

1. Introduction

The design of experiments (DoE) has become a tool of great impact in the field of engineering to improve the performance of a manufacturing process, quality improvements, the development of new product processes and engineering design at low costs (Montgomery 2017). In this way, reduce as much as possible the variability of the processes by considering the independent and dependent factors of the problem under hypothesis contrast and check if there is significant difference or not in the results of the experiment or of the process.

In this research, the experiments were conducted on the topic of fragrances, due to the growth of the beauty and personal care market worldwide. (Cien 2022) mentions that, in 2021, global sales have reached US$ 504 billion and it is expected that between 2022 and 2025, the sector will reach sales of US$ 652 billion, with an average annual growth of 5%. Figure 1 shows the highest priority segment, fragrances, increasing from $52 million in 2017 to $64 million in 2025:

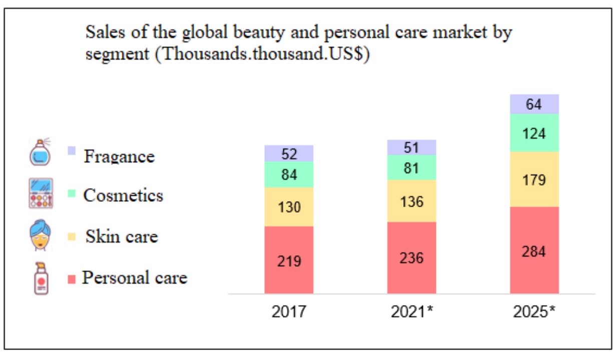

Figure 1. Global beauty and personal care market sales.
(2019 survey of more than 29,000 respondents from 40 countries- Statista/in-cosmetics Asia)

In Latin America, one of the world's largest consumers of perfumes is Brazil and the Natura brand was chosen, founded in 1969, a Brazilian multinational company of cosmetics, hygiene and beauty products, offering all-natural products and the scope to obtain them. According to (Natura 2021), the word perfume comes from the Latin "per" through - "fumum" smoke; its beginnings date back to the discovery of fire, which allowed the combustion of wood, branches, leaves and resins that gave off intense and different aromas. The passage of time, the growth of urban centers and technological advances allowed the creation of commercial perfume as we know. (Liu et al. 2022) explains that aroma is an important attribute that influences the quality perceived by the consumer and is complex to measure. There are sensory perceptions with a lot of variability due to emotions, memories, interpretation or vocabulary among tasters and measuring aroma requires arduous and lengthy training days, which are not entirely successful.

The objective of this research is to know if there is any significant difference in the duration of the fragrances, therefore, we used the completely randomized block design model (DBCA) considering as main factor four types of Natura brand perfume (EKOS, ESSENCIAL, KAIAK, HUMOR), without distinguishing the target audience (male or female) and as external variable or block were the four different tasters (Adrian, Kiara, Alvaro and Mauricio), with four samples of each one. In the block variable, which is the taster, they are the ones who will measure the duration of each perfume fragrance according to the randomized experiment and there is suspicion that they may influence the results obtained. The same randomization pattern was used for the distribution of the perfume samples to be made. The types of perfume were carefully selected within the same quality pattern to obtain homogeneity of them, and thus to know the effects of the duration times of the fragrances of these. On the other hand, the industrial engineering professional must know how to apply the design of experiments to determine if there are differences between the experimental units, thus, achieving a better analysis and reliability that will allow confirming the hypotheses set in the problem.

1.1 Objectives

The main objective of the current project is to investigate whether there is any significant difference in the duration of the fragrances of the Natura brand perfumes evaluated by 4 different tasters in 4 of the most popular Natura perfume brands among consumers.

The study is of interest due to the fact that the subjectivity of the tasters can influence the duration of the fragrances and with the experience gained, the relevance of the applicability of technology in the process of elaboration and certification of quality in the perfumes or products and support in the elaboration of new fragrances or products. Every day the perfume market is more demanding, fragrance and durability influence the moment of purchase, among other indicators and statistical tools are a great support to contribute to quality and consumer demand.

2. Literature Review

We currently live in a globalized world, where scientific and technological advances in industries are booming and DoE is a valuable statistical tool in order to obtain important variables at minimum cost and time (Román and Marco 2022). DoE, is widely used in various areas, particularly in the engineering field it is used in the design of new products, process optimization and quality or service improvement (Weisman, 2015; Politis, 2017; Santos, 2017). In the case of the cosmetics industry: Abedi et al. (2018) conducted the study of the simultaneous effect of a set of variables in the elaboration of fragrances in cosmetics and personal care products, applying the 3x23-1 fractional design of experiments, achieving an excellent combination of elements in the fragrance minimizing allergens that is harmful to health. Parente and Ares (2020), studied the visual and olfactory appearance of liquid soap to check if there are preference patterns, using the full factorial design with 3 factors and 2 levels each factor, and consumers associated the fragrance they preferred with a greater cleaning capacity and skin improvement. Carranza et al. (2020) addressed the senses in the evaluation of a perfume made with orange essential oil, the methodology used was the Taguchi design, finding the optimal combination with 4 essential elements in total, as they showed acceptable results at lower cost.

Fernandez (2022) applied the DoE completely randomized with the objective of testing the existence of a significant difference between the averages of the sensory data and the evaluations of 13 tasters in 10 fragrances of the Floral family, proving that there is a significant difference between the sensory data and the panelists. Lopez et al. (2017) studied the effect of four cosmetic formulations from natural actives, the results through the 4x2x2 factorial DoE, showed that the lotions stored in certain environmental conditions maintain stable physical and chemical characteristics and the formulations with combinations of essential oils remained with the aroma longer. Velasquez (2020) developed a completely randomized block design (CRBD) application, with 3 treatments or varieties of honey coffee, three block levels in a group of tasters and 9 experimental units in total, in order to study the honey benefit and for this purpose considered the sensory evaluation method between them fragrance/aroma. The results indicated that there is a significant difference in fragrance/aroma and panelists. Kikugava (2022), conducted research to improve the process of a cosmetics company, applying the factorial design of experiments with 3 factors, identifying the relationship of input and output variables and the relationship to the main effects and interactions obtaining significant results in the perfume line. Navarro (2021), studied the effects of the aromatic composition of wine, analyzing the combinations and interactions in the aromatic profile due to malolactic fermentation and a series of volatile decompositions with the co-inoculation technique in order to see how it affects the aromatic profile of wine, using the factorial design of experiments, improving the aroma of wine compounds.

3. Method

3.1Selecting the variable of interest

We will consider the duration time of the fragrance according to the type of perfume applied to a 15.96 cm^2. To measure these times, the centesimal stopwatches included in the following types of cell phones were used: iPhone 11, iPhone XR, Motorola Edge 20 Pro and ZT A71. It is possible that, by using different types of stopwatches for the measurement, these could be considered a block factor, but to avoid this, a preliminary measurement was performed with each one to observe if any have any measurement lag; the result of this measurement served to determine that each type of stopwatch measures equally. Also known as the dependent variable.

3.2 Selection of the independent variable

Also known as the main factor, it is considered the type of perfume belonging to the Natura brand. This brand is recognized in the international market for the natural components used in its products and consumer preference. Four types of perfumes will be analyzed, as shown in Figure 2:

- HUMOR - Peace and Humor - Sensual Herbs.
- KAIAK - Refreshing Floral.
- ESSENCIAL - Exclusive - Enveloping Woody.
- EKOS - Pitanga - Fruity Refreshing.

Figure 2. Perfume types used.

3.3 Selection of the tasters for sensory analysis

The selection of the tasters was based on the 4 students that are part of this research work, they made a very rigorous preparation before carrying out the experiment, establishing the limits and concepts of descriptive analysis of fragrances, since the duration of the type of fragrance can vary depending on who notices it and can affect the results of the experiment. Also known as block variable or external controllable variable.

3.4 Model Selection Completely Randomized Block Design

The DBCA is considered a source of external variability that is controllable and that is suspected or known to affect the response variable, called the block variable. It should be noted that the block variable is not a factor of interest in the study and should be included to obtain better results.

3.4.1 Mathematical Model

Assuming that an experiment is performed with k treatments and b blocks, the k x b data matrix will be formed, with one repetition in each combination of treatment and block. In this context, it should be considered that each measurement of the response variable under study will be the result of the effect of the treatment, the effect of the block and the random error. This is represented in the following equation:

$$Y_{ij} = \mu + \tau_i + \gamma_i + \varepsilon_{ij}, \qquad \{i = 1,2,\ldots,k \; j = 1,2,\ldots,b$$

Where:

Y_{ij} is the measurement that corresponds to the treatment *i* and to the block *j*.
μ is the global population mean.
τ_i is the effect due to the treatment *i*.
γ_i is the effect due to block *j*.
ε_{ij} is the random error attributable to the measurement Y_{ij}.

3.4.2. Analysis of variance (ANOVA)

Step 01: Hypothesis Formulation

For both the main factor and the block factor, the following hypotheses are formulated:

Null Hypothesis: $H_0: \mu_1 = \mu_2 = \ldots = \mu_k = \mu$
Alternative Hypothesis: $H_A: \mu_i = \mu_j$, for any $i \neq j$

In these hypotheses the statement to be tested is that the mean population response achieved with each treatment is the same for the k treatments, similarly with the b blocks.

Step 02: Establish a Level of Significance

Denominated by the greek letter α, it is the maximum probability that is assumed, voluntarily, of assuming the error of rejecting the null hypothesis, when it is really true; that is, it is the maximum level of error that can be made in the contrast.

The value of this probability is usually considered to be 95%, based on assumptions of normality; other values can also be used, for example, in scientific literature, ranges between 90% and 99% are usually used.

Step 03: Performing the Analysis of Variance (ANOVA)

Montgomery (2017), ANOVA is the important technique in the analysis of experimental data and the objective is to separate the total variation into the parts contributed by each source of variation in the experiment. In that sense, for a DBCA model, the hypotheses are tested with an analysis of variance with two classification criteria; in this the variability due to the treatment is separated, one for the block and the other for the random error, see in Table 1:

Table 1. ANOVA for a DBCA model.

Source of Variability	Sum of square	Degree of freedoms	Mean of square	F_0	p value
Factor	SC_{TRAT}	$k-1$	CM_{TRAT}	CM_{TRAT} / CM_E	$P(F > F_0)$
Block	SC_B	$b-1$	CM_B	CM_B / CM_E	$P(F > F_0)$
Error	SC_E	$(k-1)(b-1)$	CM_E		
Total	SC_T	$kb-1$			

To perform ANOVA it is necessary to know the values of the sums of squares. It is recommended to perform this procedure with the support of some statistical software, the most practical formulas to calculate the sums of squares are:

$$SC_T = \sum_{j=1}^{b} \sum_{i=1}^{k} Y_{ij}^2 - \frac{Y_{..}^2}{N} \qquad SC_{TRAT} = \sum_{i=1}^{k} \frac{Y_{i.}^2}{b} - \frac{Y_{..}^2}{N}$$

$$SC_{TRAT} = \sum_{i=1}^{k} \frac{Y_{i.}^2}{b} - \frac{Y_{..}^2}{N} \qquad SC_E = SC_T - SC_{TRAT} - SC_B$$

Where: $N = kb$.

Step 04: Conclusions

In this step the hypotheses are tested, both for the main factor and for the block variable. To accept or reject the null hypothesis it is necessary to analyze the *F* statistic or p_value, see Figure 3. For simplicity of analysis, we will work with the *p*_value, and the following observations will be taken in consideration:

If it is satisfied that *p_value* > α,then it is accepted H_0.

If it is satisfied that *p_value* < α, then it is accepted H_0.

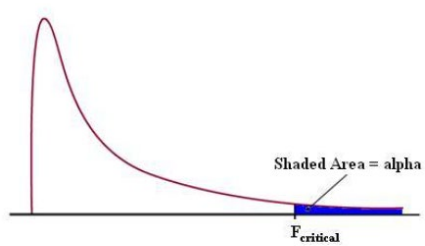

Figure 3. Acceptance and rejection region H_0 (Shaded Area)

After performing the ANOVA a, it is necessary to know if there is a significant difference between the fragrance duration time of the perfume according to the type; so it is necessary to determine which of the treatments is, or which are, different. The DMS, Tukey, Bomferroni, Duncan and other methods can be applied. In any of these methods, it is necessary to formulate the hypotheses in pairs of means. $\mu_i = \mu_j$, $i \neq j$:

H_0: $\mu_i = \mu_j$. Perfume fragrance duration time averages μ_i y μ_j are equal.

H_1: $\mu_i \neq \mu_j$. Perfume fragrance duration time averages μ_i y μ_j are different.

3.5 Basic Principles

To proceed with the experiment, it is necessary to consider the basic principles, which are important for a correct planning: randomization, repetition and blocking, which have to do directly with the data obtained being useful to answer the questions formulated.

3.5.1 Randomization

This is an important stage since it consists of executing the experimental runs in random order; this principle increases the possibility that the assumption or verification of independence of the errors is fulfilled. To implement this principle, it is necessary to perform the coding of the variables that are going to intervene in the experiment. The coding of the main factor is as follows: P1: EKOS, P2: ESSENTIAL, P3: KAIAK and P4: HUMOR.

3.5.2 Repetition

Also known as replication that consists of running a treatment more than once, to apply this principle, 4 repetitions will be conducted for each sample taken, for a total of 4 samples per brand of perfume.

3.5.3 Blocking

Regarding blocking, it consists of nullifying or adequately taking into consideration all the factors that can affect the observed response. In the experiment to be conducted, the tasters were identified as a factor that might affect the response variable, so the respective coding was done.

4. Dataset

4.1. Experiment steps

- ✓ The experiment was performed with a double draw with the coding of the perfumes and the tasters, Barriga et.al. (2022), in order to satisfy the principle of randomization and to obtain the order in which the samples were taken.
- ✓ After the drawing of lots, the random order matrix was obtained, which is shown in Table 2:

Table 2. Matrix of data results with random order.

Perfum	Teaster			
	C1	C2	C3	C4
P1	4	16	12	1
P2	3	11	15	5
P3	13	2	7	9
P4	10	8	14	6

P1: EKOS, P2: ESSENTIAL, P3: KAIAK and P4: HUMOR., Tasters: C1, C2, C3 and C4

- ✓ To control the dosage of perfume to be deposited on each 15.95 cm^2 piece of bond paper, it was considered to use 16 syringes of 5 ml per each paper.
- ✓ In each perfume with 8 ml of content, only 0.5ml was used in each syringe tube for each sample.
- ✓ The procedure was performed according to the order established in Table 2, and the instant the perfume came into contact with the respective sheet of paper, the time was measured because, although the taster is not smelling the aroma at that moment, it is evident that the fragrance is present from the first contact.
- ✓ With each bond paper ready and impregnated with the fragrance of its respective perfume, the taster to whom the order corresponded kept smelling the paper until, according to him or her, he or she could no longer perceive the fragrance of the perfume used.
- ✓ When any of the tasters did not perceive any fragrance in any of the 4 designated papers, he/she proceeded to stop the stopwatch at that very moment; this was done with each of the tasters and each of the papers with the treated samples.
- ✓ In each procedure there was a time break between tasters and each taster was separated to ensure that odors were not confused or lost.
- ✓ The data timed in centesimal minutes can be found in Table 3. The statistical analysis will be performed in RStudio and SPSS software, therefore, for data management reasons, we will work with the three-column matrix, perfume, taster and time.

Table 3. Matrix of results of timed times in minutes and seconds.

Perfum	Teaster			
	C1	C2	C3	C4
P1	45.15	46.04	45.09	44.21
P2	108.59	115.69	110.62	113.57
P3	62.35	57.20	59.24	59.00
P4	54.31	52.06	53.42	59.54

5. Results and Discussion

5.1Numerical Results-ANOVA

Formulación de hipótesis

a) Main Factor

$H_0: \mu_1 = \mu_2 = \mu_3 = \mu_4$. There is no significant difference between perfume brands in fragrance duration time by types.

$H_1: \mu_i \neq \mu_j$, at least a couple of types are different. There is a significant difference between perfume brands in the length of time the fragrance lasts depending on the type.

b) Block Factor Hypothesis

$H_0: w_1 = w_2 = w_3 = w_4$. There is no significant difference between tasters in the fragrance duration time of the perfume.

$H_1: w_i \neq w_j$, at least a couple of tasters are different. There is a significant difference between tasters in the fragrance duration time of the perfume.

On the Table 4 shows the results of the ANOVA:

Table 4. Anova - RStudio

ANOVA

```
> dataanova = aov(Tiempo ~ Perfume + Catador)
> summary(dataanova)
            Df Sum Sq Mean Sq F value   Pr(>F)    
Perfume      3  10865    3622 476.216 3.14e-10 ***
Catador      3      9       3   0.378    0.771    
Residuals    9     68       8                     
```

The following conclusions were obtained:

- ✓ Main factor: The *p_value* = $3.14 \times 10^{-10} < \alpha = 0.05$,there is evidence to reject *H0*, therefore, whether there is a significant difference between perfume brands in fragrance duration time by type.
- ✓ Block factor: The *p_value* $= 0.771 > \alpha = 0.05$, there is evidence to accept *H0*, therefore, there is no significant difference between tasters in the fragrance duration time of the perfume.

5.2 Post Hoc Analysis Results

- ✓ After performing the ANOVA, it was determined that there is a significant difference between the fragrance duration time of the perfume according to the type, which is why it is now necessary to determine which of the fragrance treatments are significant.
- ✓ It was proposed $R_2^4 = 4 \, x \, 3 = 12$ pairs of hypothesis contrasts.

The results are shown in Table 5:

Table 5. Pos Hoc Methods

	DMS	TUKEY	BOMFERRONI
p_values < α = 0.05	$\mu_{P1} \neq \mu_{p2}$, $\mu_{P1} \neq \mu_{p3}$, $\mu_{P1} \neq \mu_{p4}$, $\mu_{P2} \neq \mu_{P3}$, $\mu_{P2} \neq \mu_{P4}$, $\mu_{P3} \neq \mu_{P4}$	$\mu_{P1} \neq \mu_{p2}$, $\mu_{P1} \neq \mu_{p3}$, $\mu_{P1} \neq \mu_{p4}$, $\mu_{P2} \neq \mu_{P3}$, $\mu_{P2} \neq \mu_{P4}$,	$\mu_{P1} \neq \mu_{p2}$, $\mu_{P1} \neq \mu_{p3}$, $\mu_{P1} \neq \mu_{p4}$, $\mu_{P2} \neq \mu_{P3}$, $\mu_{P2} \neq \mu_{P4}$,
p_values > α = 0.05		$\mu_{P3} = \mu_{P4}$	$\mu_{P3} = \mu_{P4}$

Analyzing the p_values and classifying them into lower and higher than alpha for each method:

If p_value > α = 0.05, There is no evidence to reject H0, that is, there is no significant difference in the samples taken.

If p_value < α = 0.05, there is evidence to accept H0, that is, there is significant difference in the samples taken.

- ✓ By the DMS method, 6 pairs of significant samples were obtained.
- ✓ By the Tukey and Bomferroni methods, only 5 pairs of significant samples were obtained.
- ✓ It is observed that the DMS detected more of a difference in the samples that are P3 and P4.

After having performed the 3 methods (DMS, Tukey and Bonferroni), the results obtained using the DMS method will be considered, because it is more sensitive to differences. By making the box plot:

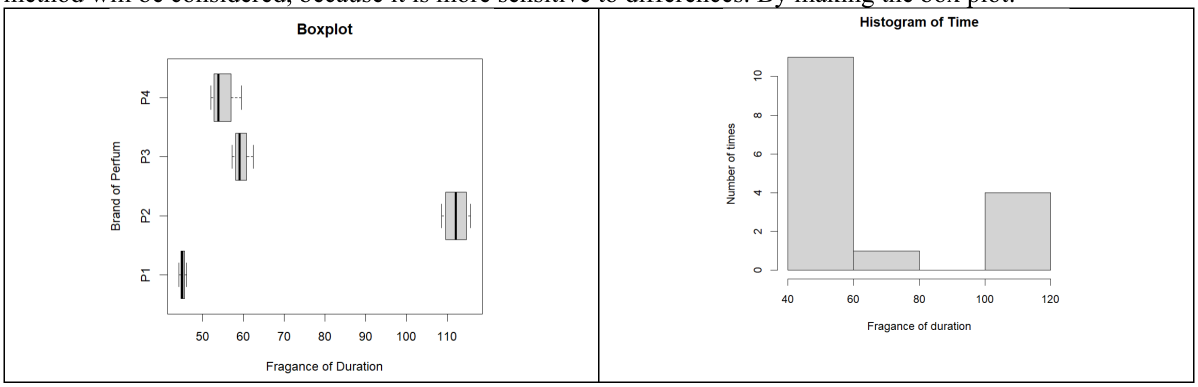

Figure 4. a) Box plot, b) Time histogram.

In Figures 4, a) we can visualize the following:

- ✓ Perfume brand 2 (ESSENCIAL) has the longest fragrance duration of 100 minutes and the shortest is perfume brand 1 (EKOS), with a duration of less than 50 minutes.
- ✓ Most of the fragrance times vary between 52 min to 60 min approximately and correspond to the P3 (KAIAK) and P4 (HUMOR) brands.
- ✓ Once the diagram is plotted, all values outside the box correspond to outliers, which are discarded for the other statistical treatments (Minnaard, 2021). In our case, no outliers are present in the data.

In Figure 4, b) we can observe that the times of P1(EKOS), P3(KAIAK) and P4 (HUMOR) are between 40 min to 60 min, the infrequent times are between 60 min to 80 min, no times of duration of the perfumes have been found between 80 min to 100 min, but the times of duration greater than 100 min if there were more cases than the previous one and corresponds to P2 (ESSENCIAL).

5.3 ANOVA Model Validation

It is important to validate the results found in the Anova.

5.31 Normality Test

The residuals should be tested to ensure that they follow a normal distribution and the following hypotheses are made: H_0: The residuals follow a normal distribution.
H_1: The residuals do not follow a normal distribution.
α = 0.05.

Table 6. Results of statistical tests in RStudio

	Shapiro Wilk test	Anderson Darling Test
P_value	`> shapiro.test(dataanova$residuals)` Shapiro-Wilk normality test data: dataanova$residuals W = 0.94175, p-value = 0.371	`> ad.test(dataanova$residuals)` Anderson-Darling normality test data: dataanova$residuals A = 0.34103, p-value = 0.4486

In the Table 6, we observe that the *p*_values are greater than alpha, in the first test on the left side the *p*_value = 0.371 > α = 0.05, and in the second test on the right side the *p*_value = 0.4486 > α = 0.05, therefore, there is evidence to accept H_0, we can say that the residuals follow a normal distribution.

5.3.2 Homoscedasticity of Variance Test

Response Variable / Main Factor

H_0: The data for perfume duration times and perfume brands are from homogeneous variances.
H_1: The data on perfume duration times and perfume brands do not come from homogeneous variances.
α = 5% = 0.05.

Table 7. Result of the Levene's test in Rstudio, Response Variable-Principal Factor.

	P_valor

Levene Test	`> levene.test(Tiempo, Perfume)`
	`Modified robust Brown-Forsythe Levene-type test based on the absolute deviations from the median`
	`data: Tiempo`
	`Test Statistic = 1.2717, p-value = 0.3282`

Barlett Test	`> bartlett.test(Tiempo, Perfume)`
	`Bartlett test of homogeneity of variances`
	`data: Tiempo and Perfume`
	`Bartlett's K-squared = 4.8536, df = 3, p-value = 0.1828`

In the Table 7, we observe that the p_values are greater than alpha, in the first row the p_value = 0.3282 > α = 0.05, and in the second row the p_value = 0.1828 > α = 0.05, therefore, there is evidence to accept H_0, we can say that, the data of perfume duration times and perfume brands come from homogeneous variances.

Response Variable / Block

H_0: The data for perfume duration times and tasters are from homogeneous variances.
H_1: The data for perfume duration times and tasters do not come from homogeneous variances.
α = 5% = 0.05.
In Table 8, we observe that the p_values are greater than alpha, in the first row the p_value = 0.9999 > α = 0.05, and in the second row the p_value = 0.997 > α = 0.05, therefore, there is evidence to accept H_0, we can say that, the data of perfume duration times and tasters come from homogeneous variances.

Table 8. Results of Levene's test in Rstudio, Variable response-Block.

	P_value

Levene Test	`> levene.test(Tiempo, Catador)`
	`Modified robust Brown-Forsythe Levene-type test based on the absolute deviations from the median`
	`data: Tiempo`
	`Test Statistic = 0.0016785, p-value = 0.9999`

Barlett Test	`> bartlett.test(Tiempo, Catador)`
	`Bartlett test of homogeneity of variances`
	`data: Tiempo and Catador`
	`Bartlett's K-squared = 0.050487, df = 3, p-value = 0.997`

5.3.2 Residual Independence Test

H_0: The data are independent of residues.
H_1: The data are not independent of residues.
α = 5% = 0.05

In Figure 5, it can be seen that there is no systematic trend to suspect that the assumption of independence is not satisfied, therefore, there is evidence to accept H_0, the data have independence of residuals.

The present work verified that the ANOVA results are reliable and the efficiency of the perfumes can be tested through the duration of the fragrance. On the other hand, analytical methods have made it possible to put into practice the study of chemometrics in the discovery of new formulas or new products.

Figure 5. Test of independence in RStudio.

Conclusions

- The model assumptions of normality, homogeneity of variance and independence of residuals were made and were verified to be satisfied by the statistical tests, the results found in the ANOVA are consistent or reliable.
- There is a significant difference between the fragrance durations of perfume types according to their type at 95% confidence, even if they belong to the same brand.
- The EKOS type of perfume has the shortest fragrance duration time, with an average of 45.12 minutes.
- The ESSENCIAL perfume type has the longest fragrance duration with an average duration of 112.12 minutes.
- The test also shows that there is no significant difference in the sensory evaluation of the tasters. The study brings the importance of understanding that the subjectivity of the tasters have no influence on the duration of the fragrances and the improvement of the perfume quality or the development of new fragrances in the market from basic chemical components such as denatured ethanol ($C2H6O$) , essence or fragrance, fixative, propylene glycol ($C3H8O2$) and distilled water ($H2O$) including the exclusive perfume components that have a longer duration of ESSENCIAL fragrance and other new components.
- Understanding the variability of the fragrance duration of perfumes is one of the essential requirements for every consumer, to select the type of perfume that can provide the best experience when using it.

Recommendations

- It is recommended to perform the experiment with more types of perfume of the same brand, in order to get to know and have a more exhaustive record of the durations of these perfumes.
- Due to the limitations of the experimenters, 2 perfumes for men and 2 perfumes for women were used, so it is suggested to separate the types of perfume according to the gender to which they are aimed.
- Due to the limitations of the experimenters, the application of these perfumes was directly to a piece of paper of 15.96 cm2; not knowing if the duration time may vary according to the surface applied; this is why it is recommended to perform it on different material surfaces, or to apply it on human skin.
- To better distinguish the perfume being tasted, it is recommended to smell cinnamon or coffee between each sample.
- In the experiment performed, a bond paper was used, but for greater precision it is recommended to use olfactory paper, which is specifically made to enable a more adequate sensory analysis.
- Apply the design of experiments of mixtures in Fragrances, based on the results obtained to optimize the composition of new combinations of components to obtain the best results in terms of quality, performance, and cost.

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