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DIFFERENCES ON THE MODIFYING INHERITANCE BETWEEN THE SPECIES; FRAGARIA VESCA L. AND FRAGARIA ANANASSA

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Summary

By modifying variability, let's mean that a certain feature of the organism undergoes changes and does not maintain uniformity during its appearance (ie during the transfer of information from the genetic structure to the phenotypic one). In this paper, it is shown how the modifying inheritance is presented in the two types of the strawberry plant, in the one that grows in nature, Fragaria vesca L., and in the one cultivated in greenhouses, Fragaria ananassa. The number of leaf teeth, of these species, has served as the analyzed feature, on which our search for this type of inheritance is based. The paper sheds light on the great role of the environment in elaborating the inheritance of organisms by causing modifying changes in their phenotype in function of the status of the environmental factors in which this organism grows and develops. When these phenotypic modifications manage to become heritable, then it is possible to deal with the action of the epigenetic effect in inheritance. For this reason, studies of modifying inheritance in the phenotype of organisms are necessary. From the comparison of the results obtained, in terms of the modification changes observed between these two species, the null Hypothesis (Ho) is rejected; so, the observed changes have a real basis and are not a random finding. Thus it becomes clear to us that the modifying changes in the inheritance of the plant grown in the natural environment (with significant changes in environmental factors) are greater than those of the species grown in strict conditions – in greenhouses (without large variations in environmental factors). Of course, these changes have an impact on the nutritional and taste values of their fruits, as they affect the nutrient processing laboratory, the leaves.

Keywords: modifying inheritance, leaves, teeth, F. vesca L., F. ananassa, number of teeth, changes, hypothesis (Ho).

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1. Introduction

Fragaria vesca L. (**Fig. 1, *a***) known as wild strawberry is a plant that belongs to the Kingdom – Platae; Clade – Tracheophytes; Clade – Angiosperm; Clade – Eudicots; Clade – Rosids; Order – Rosales; Family – Rosaceae; Genus – Fragaria; Type – F. vesca L.; Binomial name – Fragariavesca [1, 2].

Their typical habitat lies along paths and roadsides and embankments, hillsides, stone and gravel roads, meadows, young forests, sparse forests, cleared forest edges, etc. Often plants can be found where they do not receive enough light to form fruit. In the southern parts of its territory, it can only grow in shady areas, while in the northern territories it tolerates more sun. It is tolerant of a range of moisture levels (except very wet or very dry conditions) [3]. Its fruits are small and quite tasty. It is native to Europe and Asia. Varieties of this species are found everywhere. This is a compact, stemless plant, 10–20 cm tall. It has numerous, small, white, with 5–petaleds flowers with yellow centers that appear throughout the summer. The leaves are trifoliate, clearly toothed and green in color. The flowers are followed by edible, bright red strawberries (1–2 cm long) that can be picked throughout the summer. During the summer, flowers and fruits are usually present at the same time on the plant [4, 5]. The other species analyzed in this study is Fragaria ananassa (cultivated species; already present on our tables), (**Fig. 1, *b*, *c***). This is also known as the garden

strawberries. Garden strawberries were first cultivated in Britain and France in the 1750s through a cross of the North–Eastern wild species Fragaria virginiana with the other wild species Fragaria chiloensis (beach or coast strawberry), which was brought from Chile by Amédée–François Frézier in 1714. Cultivars of Fragaria × ananassa have replaced, in commercial production, the forest strawberry (Fragaria vesca), which was the first strawberry species cultivated in the early 17th century [2]. This is a compact, stemless plant, 15–30 cm tall. It has large, white, with 5-petaled flowers with yellow centers. The size of their fruit varies from 3 cm to over 10 cm. Their taste in relation to wild ones presents many differences since they do not contain qualitative spicy substances in the same percentages as natural plants [6].



a *b* *c*

Fig. 1. Strawberry: *a* – flowers and fruits of F. vesca L.; *b* – flower of F. ananassa; *c* – fruits of F. ananassa

2. Materials and methods

Since in the genus Fragaria let's find a biological diversity, combined with the availability of genomic resources and the ease of growing and experimenting with these plants, this made Fragaria a very attractive system for ecological and evolutionary genomics [7, 8]. Precisely for this purpose, it is possible to analyze the feature of the leaf teeth on the plants in question. Thus, it is possible to analyze a sample of 300 randomly collected leaves in different plant individuals for both F. vesca and F. ananassa; so, a total of 600 leaves. The teeth of each of 300 leaves of F. vesca and 300 leaves of F. ananassa is counted. The collected data were then statistically processed in order to identify possible changes in the process of the modifying inheritance from one species to another (on the basis of what they, their growth and development, do in environmental conditions that are not unique). All the collected and acquired data came from our direct observations as well as from their statistical processing through SPSS software – V.21 [9, 10]. Graphical and tabular illustrations of the results of statistical processing (using the elements of descriptive statistics) of the above data allowed to conclude about the differences between the statistical parameters that appear for the two varieties of strawberries taken in the study. To verify the statistical stability of the identified changes, let's use the "*t*" test (*t*–test) for the comparison of means, with the null hypothesis "there is no difference in the modifying inheritance expressed by the number of leaf teeth, in Fragaria vesca L. and Fragaria ananassa varieties." [11] The results obtained through inferential statistics led to conclusions that reject the null Hypothesis (Ho), making present, within an acceptable error (0.05), the real different value of the modifying inheritance between these two species taken into analysis.

3. Results and discussions

The number of leaf teeth of F. vesca, for the sample of 300 leaves, is given below (**Fig. 2**).

After processing these data, through the SPSS–V.21 software, the results of the descriptive statistics, for the number of teeth on the leaves of F. vesca L., for a sample of 300 leaves, collected randomly (**Table 1**), show that:

– the amplitude (Range) of the survey is 29–9=20 units, with the median 19 and Mode nr.20;

– the average (Mean) of the number of teeth is estimated at 18.52 units and the Variance is approximately 7.42 units.

22	15	15	15	17		19	20	13	19	20		22	20	20	14	12
21	21	20	12	29		20	21	20	19	20		16	16	15	22	19
23	19	16	15	18		15	15	09	09	12		20	14	14	22	20
20	20	19	18	20		19	17	18	20	13		19	20	19	18	21
19	18	17	17	18		23	21	16	16	16		20	22	20	15	17
21	22	21	19	20		14	15	15	18	19		14	14	24	14	20
20	20	12	19	21		18	22	21	15	15		22	18	14	15	19
14	16	18	15	19		20	20	14	19	22		18	17	14	18	16
18	17	18	21	18		20	18	21	21	20		18	18	19	19	19
18	17	23	23	21		21	23	21	21	17		21	20	20	14	14
20	12	19	19	13		19	22	20	21	18		18	15	21	23	21
18	19	19	19	20		18	23	22	21	22		17	15	18	18	17
22	20	13	18	17		20	22	16	18	21		12	18	18	16	17
17	17	16	20	19		19	20	15	16	19		17	16	18	22	21
18	20	18	18	16		17	20	19	19	18		22	21	20	19	20
17	22	17	20	21		19	21	20	20	20		25	22	17	20	22
20	16	20	21	19		18	20	19	21	20		19	21	18	21	20
20	20	18	19	17		19	15	13	19	18		21	21	18	18	18
19	18	15	18	18		18	18	21	20	15		20	22	20	23	19
20	19	18	19	19		18	20	22	14	21		19	19	18	17	16

Fig. 2. The number of leaf teeth of F. vesca, for the sample of 300 leaves

Table 1

Results of the descriptive statistic for Fragaria vesca L.

Natural					Statistics		
Valid	**Frequency**	**Percent**	**Valid percent**	**Cumulative percent**	**Natural**	–	–
9.00	2	0.7	0.7	0.7	N	Valid	300
12.00	6	2.0	2.0	2.7		Missing	0
13.00	5	1.7	1.7	4.3	Mean		18.5200
14.00	14	4.7	4.7	9.0	Median		19.0000
15.00	20	6.7	6.7	15.7	Mode		20.00
16.00	16	5.3	5.3	21.0	Std. Deviation		2.72783
17.00	22	7.3	7.3	28.3	Variance		7.441
18.00	49	16.3	16.3	44.7	Range		20.00
19.00	45	15.0	15.0	59.7	Minimum		9.00
20.00	55	18.3	18.3	78.0	Maximum		29.00
21.00	34	11.3	11.3	89.3		25	17.0000
22.00	21	7.0	7.0	96.3	Percentiles	50	19.0000
23.00	8	2.7	2.7	99.0		75	20.0000
24.00	1	0.3	0.3	99.3	–	–	–
25.00	1	0.3	0.3	99.7	–	–	–
29.00	1	0.3	0.3	100.0	–	–	–
Total	300	100.0	100.0	–	–	–	–

Referring to **Fig. 3**, which presents the interquartile distribution of the number of indentations in the leaves of Fragaria vesca L., it is possible to observe that the central concentration (50 % – rain of the survey) is projected in a narrow interval between 17 and 20 indentations, thus realizing an interquartile difference of 20–17=3 units. Also, the box–plot of the interquartile distribution shows that values above 23 digits and below 13 digits appear as outliers. So, the statistically significant values of the number of denticles in the leaf of Fragaria vesca L., excluding outliers, range from 13 to 23 denticles.

The approximation to the normal distribution (Gaussian distribution) simulated by the SPSS software, using the statistical parameters calculated using the data provided by the Fragaria vesca L. leaf sample, is represented by the blue line in **Fig. 4**, while the real distribution of the densities

of the number of indentations in the leaves of Fragaria vesca L., is presented by the green line. The discrepancy between them is obvious.

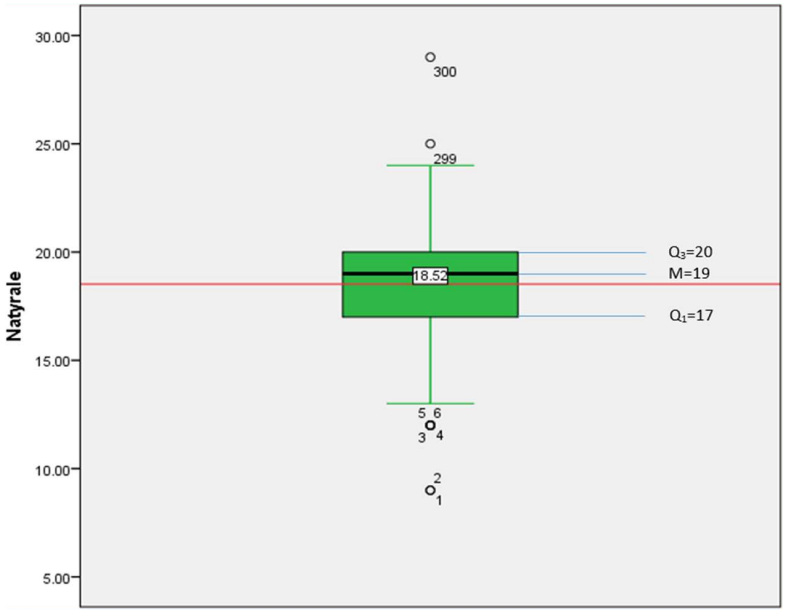


Fig. 3. Interquartile distribution for Fragaria vesca L

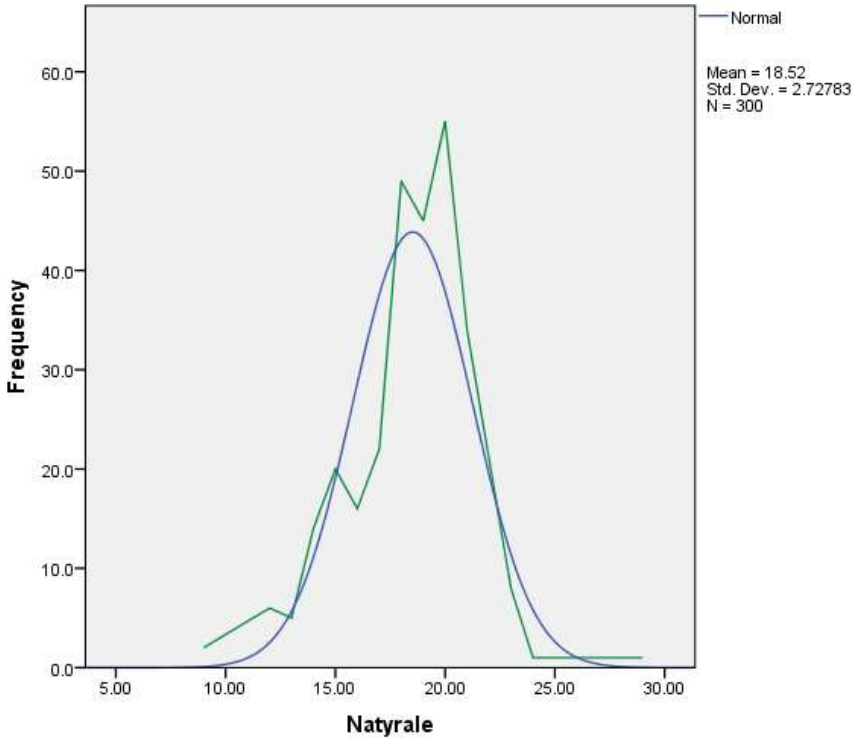


Fig. 4. Comparison of the sample distribution with the normal distribution

The statistical processing of the data in order to calculate the interval estimate with probability of significance α=0.05, for the average number of indentations in the leaves of Fragaria vesca L., has given the results shown in **Table 2**. From this table it is possible to see that the lower limit of the number of denticles on the leaves of Fragaria vesca L., with a probability of 95 %, is approximately

18 units, while the upper limit is approximately 19 units, giving a length of the interval estimation interval which does not exceed one unit (18.8299–18.2101=0.6198).

Table 2

Interval estimate for the mean (case Fragaria vesca L.)

One – Sample Test						
Specie	**Test Value=0**					
	t	***df***	**Sig. (2-tailed)**	**Mean Difference**	**Interval of the**	
					Lower	**Upper**
Natural	117.594	299	0.000	18.52000	18.2101	18.8299

The number of the leaf denticles of the cultivated strawberry, Fragaria ananassa, for the sample of 300 leaves, is given below (**Fig. 5**).

17	18	19	16	16		25	17	18	16	21		17	17	16	16	15
15	18	16	18	16		15	18	15	14	15		18	15	15	16	19
15	13	12	13	13		17	15	16	15	15		22	18	17	22	21
15	14	17	18	19		17	17	17	16	20		16	15	18	18	16
19	22	21	17	13		19	12	17	17	16		22	19	14	16	16
19	17	14	17	18		18	17	11	16	16		17	15	15	18	16
14	20	14	18	19		17	16	14	16	17		17	16	16	20	15
16	15	15	17	15		12	13	15	14	17		20	16	16	15	17
14	15	14	15	14		15	12	17	18	20		14	16	16	15	16
16	18	19	16	17		17	19	18	19	16		16	24	15	17	19
17	17	17	18	20		15	18	16	16	16		16	15	18	16	18
18	18	16	18	18		19	15	19	17	19		18	14	16	17	17
17	18	18	12	15		16	15	16	17	17		13	14	13	19	13
14	14	17	17	16		15	14	16	15	16		14	11	14	18	18
15	15	18	17	17		18	17	16	18	15		18	15	21	15	23
17	14	18	16	17		16	18	17	16	16		16	17	16	20	18
16	14	16	12	15		17	20	17	16	16		14	15	14	22	14
17	17	19	18	18		15	16	15	17	19		13	16	18	16	16
17	17	20	18	13		17	21	19	18	16		13	18	18	13	15
18	17	19	16	17		16	16	15	15	18		18	19	16	15	15

Fig. 5. The number of leaf teeth of F. ananassa, for the sample of 300 leaves

The results of the descriptive statistic for the number of denticles on the leaves of Fragaria ananassa for a sample of 300 randomly collected leaves (**Table 3**), show that:

– amplitude (range) of observation is 25–11=14 units, with Median 16 and Mode number 16;

– the mean (mean) of the number of denticles is estimated at approximately 16.54 units and the Variance at approximately 4.62 units.

Referring to **Fig. 6**, which presents the interquartile distribution of the number of teeth in the leaves of Fragaria ananassa, it is possible to note that the central concentration of 50 % of the survey is projected in a narrow interval between 15 and 18 teeth, thus realizing an interquartile difference of 18–15=3 units. Also, the box–plot of the interquartile distribution shows that values above 22 digits appear as upper outliers. So, the statistically significant values of the number of denticles in the Fragariaananassa leaf, excluding the outliers, range from 11 to 22 denticles.

The approximation to the normal distribution (Gaussian distribution) simulated by the SPSS software, using the statistical parameters calculated using the data provided by the Fragaria ananassa leaf sample, is represented by the blue line in **Fig. 7**, while the real distribution of the densities of the number of indentations in the leaves of Fragaria ananassa is represented by the red line.

Comparing the graphs shown in **Fig. 4, 6**, it is clearly observed that the Fragaria ananassa variety of the cultivated strawberry has a much clearer match than in the case of the Fragaria vesca L. (wild strawberry) variety.

Table 3

Results of descriptive statistic for Fragaria ananassa

Modified					Statistics		
Valid	**Frequency**	**Percent**	**Valid percent**	**Cumulative percent**	**Modified**		
11.00	2	0.7	0.7	0.7	N	Valid	300
12.00	6	2.0	2.0	2.7		Missing	0
13.00	12	4.0	4.0	6.7	Mean		16.5367
14.00	24	8.0	8.0	14.7	Median		16.0000
15.00	46	15.3	15.3	30.0	Mode		16.00
16.00	66	22.0	22.0	52.0	Std. Deviation		2.14881
17.00	55	18.3	18.3	70.3	Variance		4.617
18.00	46	15.3	15.3	85.7	Range		14.00
19.00	21	7.0	7.0	92.7	Minimum		11.00
20.00	9	3.0	3.0	95.7	Maximum		25.00
21.00	5	1.7	1.7	97.3		25	15.0000
22.00	5	1.7	1.7	99.0	Percentiles	50	16.0000
23.00	1	.3	.3	99.3		75	18.0000
24.00	1	.3	.3	99.7			
25.00	1	.3	.3	100.0	–		
Total	300	100.0	100.0	–			

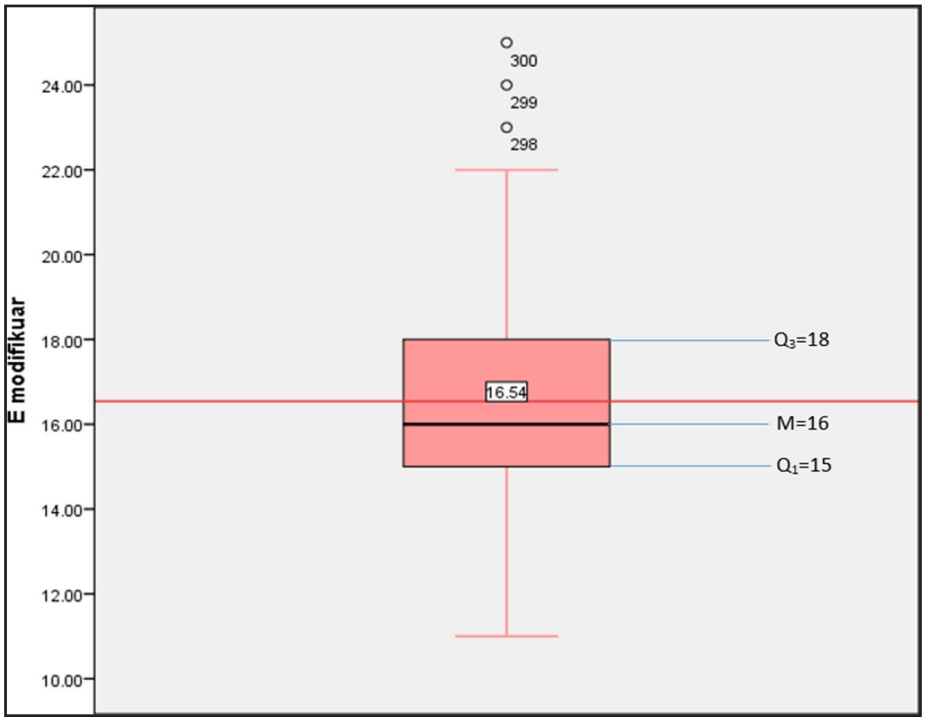


Fig. 6. Interquartile distribution for Fragaria ananassa

The statistical processing of the data in order to calculate the interval estimate with significance probability α=0.05, for the average number of teeth on the leaves of Fragaria ananassa, has given the results shown in **Table 4**. From this table it is possible to see that the lower limit of the number of denticles on the leaves of Fragaria ananassa, with a probability of 95 %, is approximately 16 units, while the upper limit is approximately 17 units, giving an interval estimation with interval length which does not exceed one unit (16.7808–16.2925=0.4883).

Comparing the two species in question, based on the processing of our data, the following results were obtained (**Table 5**):

– the amplitudes of observation show obvious variability; for Fragaria vesca L. it is 20 units while for Fragaria ananassa it is 14 units. Likewise, the medians and modes are clearly different for the two respective samples. The median for Fragaria vesca L. is 19 while for Fragaria ananassa it is 16. The mode for Fragaria vesca L. is 20 while for Fragaria ananassa it is 16. So as can be seen, for Fragaria vesca L., different values are projected for the median and mode, while for Fragaria ananassa they match;

– visible are the differences of the expected values for the average number of indentations in the respective leaves. For Fragaria vesca L. it is 18.52 units while for Fragaria ananassa it is 16.54 units. The standard error in the estimation of the expected averages is approximately equal for both varieties (**Table 6**). An obvious difference also appears in the values of the variances and consequently also in their standard deviations (**Table 6**). For Fragaria vesca L. the variance is approximately 7.44 units, while for Fragaria ananassa it is approximately 4.62 units.

The results of the descriptive statistics summarized in **Table 5** for both strawberry varieties allow to conclude about a significant difference in the statistical parameters in terms of the number of indentations on the respective leaves.

The interquartile range (Length of the central 50 % interval) is the same (3 units) for both varieties, but the actual limits of the respective central 50 % intervals differ significantly. For Fragaria vesca L. they are from 17 to 20 units and for Fragaria ananassa they are from 15 to 18 units. The difference between the expected means is estimated at almost 2 units (Mean=1.98333, **Table 7**) with a standard deviation of approximately one unit (St.Dev.=0.93415, **Table 7**).

Interval estimates of the mean number of indentations on the leaves of the two varieties (**Tables 2, 4**) are mathematically distinct as they result in two compact communities which are not expected (have no common element).

After the evidence of this multitude of changes in the statistical parameters of the samples taken from Fragaria vesca L. and Fragaria ananassa, as far as the number of teeth on their leaves is concerned, the question naturally arises: are these qualitative changes statistically stable or are they random results dedicated to the selection of two leaf samples from Fragaria vesca L. and Fragaria ananassa.

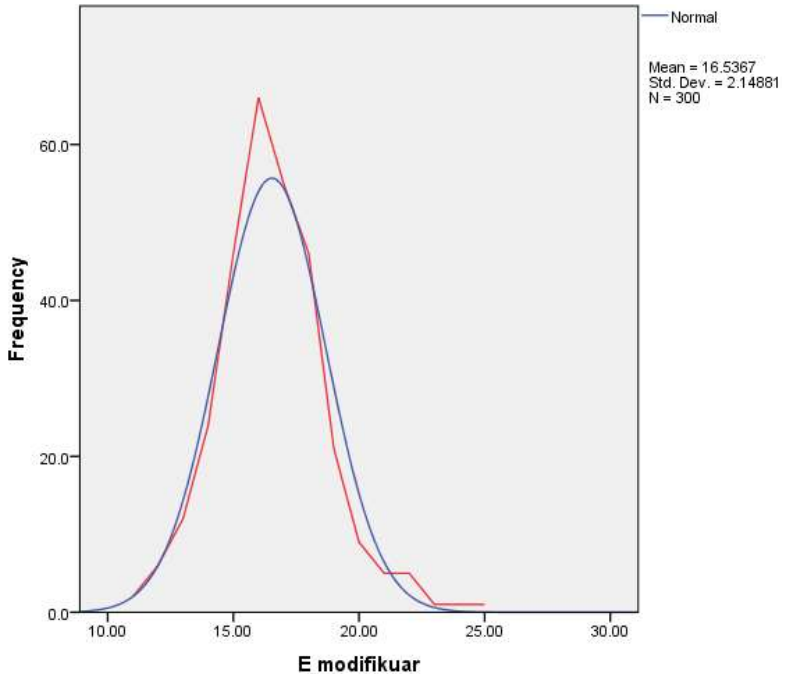


Fig. 7. Comparison of the sample distribution with the normal distribution

Table 4

Interval estimation for the average (Fragaria ananassa case)

One – Sample Test						
Specie	Test Value=0					
	t	*df*	Sig. (2-tailed)	Mean Difference	Interval of the	
					Lower	Upper
Modified	133.294	299	0.000	16.53667	16.2925	16.7808

Table 5

Comparison of results between the natural (wild) species Fragaria vesca L. and the modified (cultivated) Fragaria ananassa

Statistics			
Two Species		Natural	Modified
N	Valid	300	300
	Missing	0	0
Mean		18.5200	16.5367
Median		19.0000	16.0000
Mode		20.00	16.00
Std. Deviation		2.72783	2.14881
Variance		7.441	4.617
Range		20.00	14.00
Minimum		9.00	11.00
Maximum		29.00	25.00
Percentiles	25	17.0000	15.0000
	50	19.0000	16.0000
	75	20.0000	18.0000

Table 6

Paired samples statistics

Paired samples statistics					
Two species		Mean	*N*	Std. deviation	Std. error mean
Pair I	Natural	18.5200	300	2.72783	0.15749
	Modified	16.5367	300	2.14881	0.12406

Table 7

Paired samples test

Paired Samples Test									
Species		Paired Differences					*t*	*df*	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	Interval of the				
					Lower	Upper			
Pair 1	Natural Modified	1.98333	0.93415	0.05393	1.87720	2.08947	36.774	299	0.000

To answer this question, let's use t–test to compare the two averages in order to verify the null hypothesis, Ho: There is no significant difference between the number of indentations in the leaves of Fragaria vesca L. and Fragaria ananassa. The critical value of the t–test for the case of our sample with 300 pairs and therefore with 598 degrees of freedom as well as a margin of statistical error no higher than 5 %, was calculated using the "T–Value Calculator" software (**Fig. 8**). This critical value results to=1.9644 (**Fig. 8**).

The *t*–test value for the data of our survey is *t*=36.774 (**Table 7**). Since *t*>to, then the null hypothesis (Ho) is rejected and therefore the alternative hypothesis Ha is accepted with 95 % certain-

ty. The change in the number of indentations in the leaves of Fragaria vesca L. and Fragaria ananassa is statistically significant with an average change of approximately 2 units and a standard deviation of this change that does not exceed one unit.

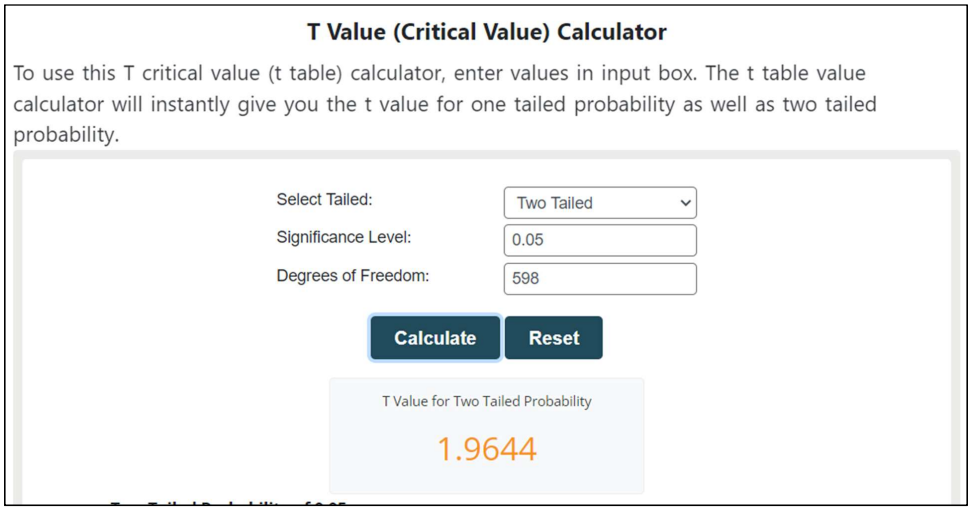


Fig. 8. Comparative values for the *t*–test (verification of the hypothesis Ho)

4. Conclusions

From our results it is observed that in both species there is a deviation from the normal distribution of the traits of the number of leaf denticles in these two species (**Fig. 4, 6**).

In **Fig. 4** it can be seen that the (actual) distribution of the values of this feature – in green, in relation to the normal distribution (theoretically expected) – in blue (for F. vesca) has significant changes in relation to those given in figure 6 (the actual distribution – red color and the expected theoretical one – in blue color (for F. ananassa). This shows that the modifying inheritance in function of environmental factors is much more evident in F. vesca than in F. ananassa.

Looking at the critical value (**Fig. 8**) the fact of the modifying changes is a scientifically supported hypothesis as the null Hypothesis (of no changes) falls. So there are changes and here it is not deal with possible experimental errors since the certainty of the event is very high due to the fact of the margin of error which in our case is completely negligible, only 0.05 (**Fig. 5**).

These changes of the modifying inheritance give the species a higher adaptive value, making it more vital and more resistant even to the adverse conditions of the environment where it grows. The changes of these features also have an effect on the quality of the fruits of the plant, that is, with an impact on their nutritional and taste values.

Conflict of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The study was performed without financial support.

Data availability

Manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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