# The Effect of Oregano Essential Oil Addition on Milk Production and Composition of Organically Reared Goats

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**Abstract**
The effect of adding organic oregano essential oil (EO) to the diet of dairy goats was investigated. Twenty-four age-matched lactating goats, mean live weight 49±1.8 kg, were allocated to 3 equal groups in a randomized design, of 8 goats housed in the same cell. The 3 groups were fed the same standard mixture of corn-based concentrates, while a mixture of alfalfa hay, wheat straw and corn silage were used as roughage. In groups 2 and 3, organic oregano essential oil 1ml and 2ml per animal per day was added to the concentrate feed mixture. Individual milk production performance as well as ration provision was recorded daily, starting from the 150th day of milk production. The milk samples were analyzed for their chemical composition and the number of somatic cells. The results showed that the groups of animals with the inclusion of EO showed a greater persistence in milk production compared to the control group. In addition, groups 2 and 3 presented 21.4% and 10% increased milk production compared to group 1, during the final stage of milk production. The chemical analysis of the milk showed that group 2 showed the highest fat content and protein concentration, as well as that the milk from groups 2 and 3 showed a lower number of somatic cells, compared to group 1. In conclusion, EO supplementation can improve the performance of organically reared dairy goats as well as relatively improve the composition of the milk produced. However, the underlying mechanisms leading to this improvement need further investigation.

**Key words:** dairy goats, milk yield, oregano essential oil

## 1. Introduction

Goat milk production is an important livestock activity both in Greece and throughout the Mediterranean basin. In the case of Greece, the goat's milk participates in the production of a significant number of Protected Denomination of Origin (PDO) cheeses. The world production of goat milk reached 22.37 million tons in the year 2022 and shows an increase of 20% compared to the previous decade [1]. On the contrary, in Greece in the same decade there was a 24% decrease in the total amount of goat milk yield which reached 0.35 million tons in the year 2022 [2]. Similar was the drop in the production of goat milk cheese which amounted to approximately 37,000 tons in the year 2021. This decrease in milk production was due to the reduction of the total reared goat population in the last decade by approximately 40%. This change has also affected the traditional pastoral way of rearing goats, where more intensive rearing systems have been adopted with mechanical milking that have increased the productivity of the animals.

In the present study, an attempt is made to examine the improvement that can be caused in the yields of an intensive goat rearing that has adopted the use of organically produced feed, by

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the addition of essential oil (EO) of organic oregano (*Origanum vulgare L.*). The principal compounds of oregano EO are carvacrol, thymol, γ-terpinene, p-cimene and linalool. The oregano EO has been reported to present remarkable biological properties. Particularly, it has been shown to exhibit powerful antimicrobial, antimycotic, antioxidant, anti-inflammatory and insecticidal activity, which result from its phenolic content and mainly from its major component, carvacrol [3].

The need to reduce the somatic cells in milk in order to produce high quality cheese products in combination with the ban on the use of antibiotics and the control of their residues in the EU, has led researchers to study the use of alternative performance enhancers such as essential oil extracts of aromatic plants [4, 5]. Essential oils are volatile aromatic compounds produced by plants (herbs and spices) as complex mixtures of secondary metabolites.

The addition of essential oils derived from certain plant extracts to the rumen can interact with microbial cell membranes and inhibit the growth of gram ± bacteria. This results in the inhibition of deamination and methanogenesis, resulting in lower production of ammonia, methane and acetic acid and increasing the concentration of propionic and butyric acids [6]. Also feed efficiency was improved when feeding OEO via stimulating the beneficial gut microbes while inhibiting pathogenic microorganism growth, i.e. *Escherichia coli*, *Staphylococcus aureus* [7] and *Pasterrella. Aeruginosa* [8].

Moreover, Zhou et al. (2019) [9] found that supplying low amount of oregano EO could have positive effects on ruminal microbial populations, whereas supplying elevated doses of EO could be detrimental to those same ruminal microbial populations.

The aim of the current study was to investigate the possible improvement in milk production and the characteristics of milk derived from dairy goats that have been fed with rations enriched with organic oregano essential oil, in amounts of 1 and 2 ml per animal/day.

## 2. Materials and methods

In order to carry out the experiment, a random sample of twenty-four (24) milking goats of Alpine breed was selected from a total herd of 450 goats kept in the Regional Unit of Evros, Greece. Selection criteria were only the same age and lactating period of the selected goats, which had an average body weight of 49±1.8 kg.

The goats were divided into three treatment groups of eight animals each. Group 1, which was the control, was given the standard binary ration of roughage and concentrated organic feed. In groups 2 and 3, 1ml and 2ml organic oregano essential oil was added to the concentrate feed mixture per animal and day respectively. The ration was given twice in the morning and in the afternoon after milking.

The daily roughage supply reached 2 kg and consisted of 1.2 Kg alfalfa hay (Moisture 8.83%, Protein 11.74%, Ash 7.53%, NDF 53.44%, ADF 31.27%, Crude fiber 34.4%, Fat 1.66%, Calcium 0.35%, Phosphorus 0.23%), 0.3 Kg wheat straw (Moisture 8.56%, Protein 5.22%, Ash 5.88%, NDF 56.54%, ADF 34.43%, Crude fiber 37.18%, Fat 1.34%, Calcium 0.33%, Phosphorus 0,18%) and 0.5 Kg maize silage (Moisture 62.34%, Protein 8.12%, Ash 5.88%, NDF 34.41%, ADF 16.27%, Crude fiber 12.32%, Fat 1.34%. Calcium 0.03%. Phosphorus 0,06%). Regarding the concentrated feed mixture, the daily supply reached 1.2Kg and its composition was 50% corn, 20% soybean meal, 13% bran, 6% barley, 6% triticale and 5% (Moisture 11.96%, Protein 21.15%, Fat 4.68%, Fiber 3.77%, NDF 9.95%, ADF 2.6%, ADL 0.62%, Starch 50.94%, Ash 1.82%, Calcium 1.77%, Phosphorus 0.44%) inorganic and vitamin premix. The incorporation of organic oregano essential oil into the ration was done using Tween 80 (Polysorbate 80) emulsifier, in a quantity of 2ml per animal and day, in each group, including the control. During the experiment, the goats were kept in group pens of 8 individuals and had free access to water.

The trial started on the 150th day of milk production and lasted for 60 days after a 15-day adjustment period, where the daily amount of milk production was measured individually. The starting day of the experiment, the 15th, the 30th, the 45th and the 60th day of its implementation were defined as days of milk counting. All goats in the sample were machine-milked twice daily (at 07:00 and 17:00 h) in milking parlor with an identification mechanism for each goat (ruminal bolus). Individual milk samples were analyzed for fat, protein, lactose, total solids, somatic cell count

(SCC) and solids not fat (SNF), by using the facilities and equipment of HAO-Demeter (Hellenic Agricultural Organisation-Demeter) in Paralimni/Regional Unit of Pella.

The data obtained concerning total milk production and composition were initially tabulated in MS-Excel worksheets and then the existence of statistically significant differences in the mean values was tested using one-way ANOVA tests in SPSS-24 environment.

## 3. Results and discussion

The collected data related to the amount of milk production and milk components were considered as the variables entered the SPSS for statistical processing. Descriptive statistics results are analyzed in table 1 for each group and aggregated. Regarding variable milk production, the results showed that the groups of goats with the inclusion of EO showed a greater persistence in milk production compared to the control group. Groups 2 and 3 according to the data in Table 1 show, increased milk production compared to the control by 13.3% and 3.3% respectively.

In addition, groups 2 and 3 presented 21.4% and 10% increased milk production compared to group 1, during the final stage of milk production. The differences between groups are also shown in Figure 1.

**Table 1.** The descriptive statistics of the experiment measurements (at 95% Confidence Interval for Mean)

| Variables | | Mean | Std. deviation | Std. Error | Min. | Max. |
|---|---|---|---|---|---|---|
| Milk production | Group 1 | 1345.34 | 421.154 | 74.450 | 406.00 | 1979.00 |
| | Group 2 | 1524.93 | 475.070 | 83.981 | 771.00 | 2604.00 |
| | Group 3 | 1390.21 | 446.693 | 78.965 | 642.00 | 2469.00 |
| | Total | 1420.16 | 450.025 | 45.930 | 406.00 | 2604.00 |
| Fat % | Group 1 | 5.01 | .846 | .149 | 3.32 | 7.64 |
| | Group 2 | 4.96 | .768 | .136 | 3.11 | 6.37 |
| | Group 3 | 4.97 | 1.003 | .177 | 3.64 | 7.25 |
| | Total | 4.98 | .869 | .089 | 3.11 | 7.64 |
| Protein % | Group 1 | 3.96 | .467 | .083 | 2.84 | 4.92 |
| | Group 2 | 4.20 | .429 | .076 | 3.44 | 5.18 |
| | Group 3 | 4.01 | .638 | .113 | 3.06 | 5.19 |
| | Total | 4.06 | .525 | .054 | 2.84 | 5.19 |
| Lactose % | Group 1 | 4.56 | .279 | .049 | 3.50 | 4.90 |
| | Group 2 | 4.37 | .130 | .023 | 4.08 | 4.59 |
| | Group 3 | 4.46 | .287 | .051 | 3.45 | 4.83 |
| | Total | 4.46 | .253 | .026 | 3.45 | 4.90 |
| Total Solids % | Group 1 | 14.32 | 1.155 | .204 | 11.66 | 17.14 |
| | Group 2 | 14.28 | .996 | .176 | 12.39 | 16.29 |
| | Group 3 | 14.19 | 1.490 | .264 | 11.89 | 17.23 |
| | Total | 14.26 | 1.220 | .124 | 11.66 | 17.23 |
| Somatic Cell Count *1000/ml | Group 1 | 2262.75 | 5041.519 | 891.223 | 46.00 | 20109.00 |
| | Group 2 | 2411.84 | 2803.318 | 495.561 | 57.00 | 11333.00 |
| | Group 3 | 2337.44 | 4885.125 | 863.576 | 111.00 | 28045.00 |
| | Total | 2337.34 | 4318.496 | 440.754 | 46.00 | 28045.00 |
| Total Colony Count *1000/ml | Group 1 | 354.78 | 1066.945 | 188.611 | 8.00 | 4506.00 |
| | Group 2 | 108.69 | 284.904 | 50.364 | 8.00 | 1538.00 |
| | Group 3 | 215.53 | 810.990 | 143.364 | 8.00 | 4611.00 |
| | Total | 226.33 | 789.199 | 80.547 | 8.00 | 4611.00 |

It was also checked if there were significant differences in the values of the variables between the experimental groups, as shown in table 2. From the data in table 2, there are no statistically significant differences at a=0.05 level of significance in the variables (excluding the Lactose variable – which is not significant, however, Figure 2).

The next statistical test concerned whether there were significant differences in variable values between treatments and days is presented in Table 3. For a better interpretation of the results the *p-value* (=.001) is lower than the alpha level of .05 so the null hypothesis can be rejected, and the alternative hypothesis can be accepted.

The results in Table 3 show that the differencesare statistically significant for the variables: milk production, fat%, protein%, and total solids%. That is, the interactions between treatment and time were significant for most of the parameters measured. Indicatively, the decline in milk production over time is shown in Figure 3.

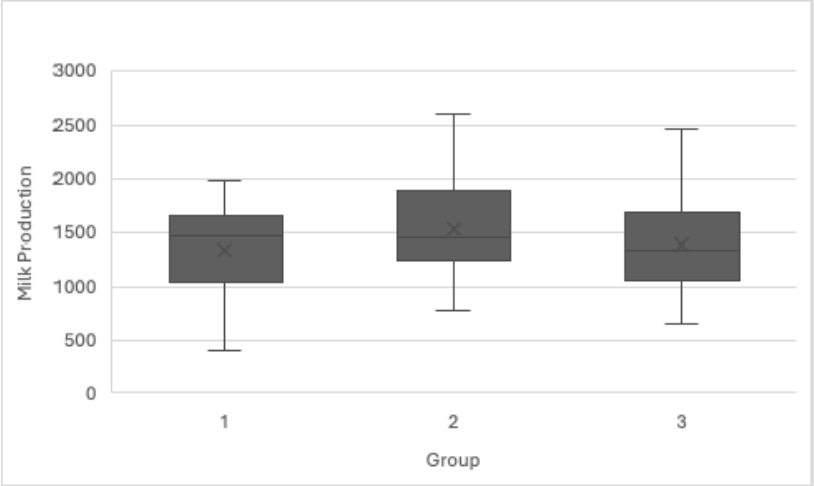


**Figure 1.** The differences between groups in the amount of milk production

**Table 2.** Comparisons of variable values between groups

| Variables | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Milk Production * Group | 559112.771 | 2 | 279556.385 | 1.392 | .254 |
| Fat% * Group | .038 | 2 | .019 | .025 | .976 |
| Protein% * Group | 1.051 | 2 | .525 | 1.944 | .149 |

Overall, in our trial, feeding Alpine goats with organic oregano EO increased milk production compared with the control group. The addition of twice the amount of EO in group 3 did not give a linear increase in milk production following the satisfactory increase shown by group 2 compared to the control. In general, the decline in milk production over time is satisfactory given that the animals are at the end of the lactation period.

Also observing figure 3 a trend of improvement in the persistence of milk production is concluded. No interaction was observed between EO addition and milk composition, except for lactose. Similar results were reached by Giannenas et al. (2011) [4] where addition of an EO formulation to dairy sheep resulted in increased milk production due to improved ration utilization and no statistically significant effect on milk composition.

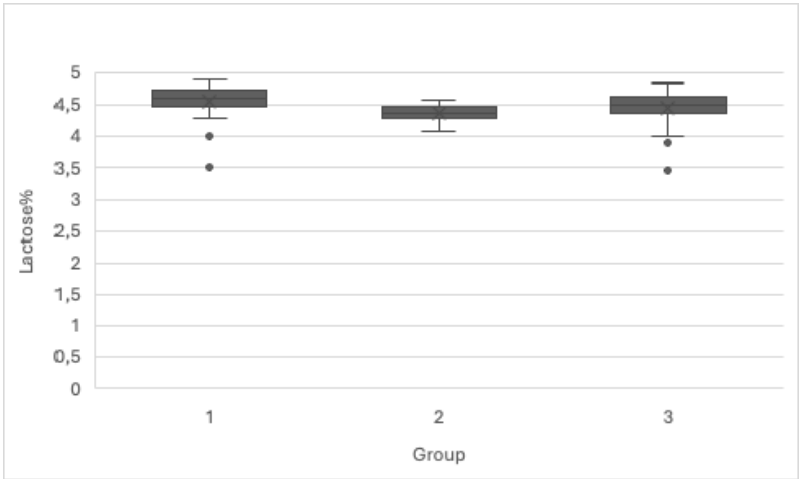


**Figure 2.** The differences between groups in the percentage of lactose

They also found that rumen pH was not affected by EO supplementation, but acetate rumen concentrations tended to increase and propionate. In the research by Zhou et al. (2019) [9] which was about the effect of oregano EO on the ruminal pH and microbial population of sheep it was found that supplying EO could have positive effects on ruminal microbial populations. Ozcinar and Bayram, (2021) [5] claim that essential oils added during the late lactation period can not only positively contribute to milk quality and yield but also to improve fat, protein and lactose contents of milk and have effects in rumen content and antimicrobial effects.

**Table 3.** Multiple comparisons of variable values between groups (combined)

| Variables | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Milk Production * Days | 8918959.250 | 3 | 2792986.417 | 26.502 | <.001 |
| Fat% * Days | 18.900 | 3 | 6.300 | 10.973 | <.001 |
| Protein% * Days | 5.533 | 3 | 1.844 | 8.218 | <.001 |
| Lactose% * Days | .129 | 3 | .043 | .666 | .575 |
| Total Solids% * Days | 33.795 | 3 | 11.265 | 9.637 | <.001 |
| Somatic Cell Count *1000/ml * Days | 92295347.2 | 3 | 30765115.7 | 1.685 | .176 |
| Total Colony Count *1000/ml * Days | 2252986.833 | 3 | 750995.611 | 1.214 | .309 |

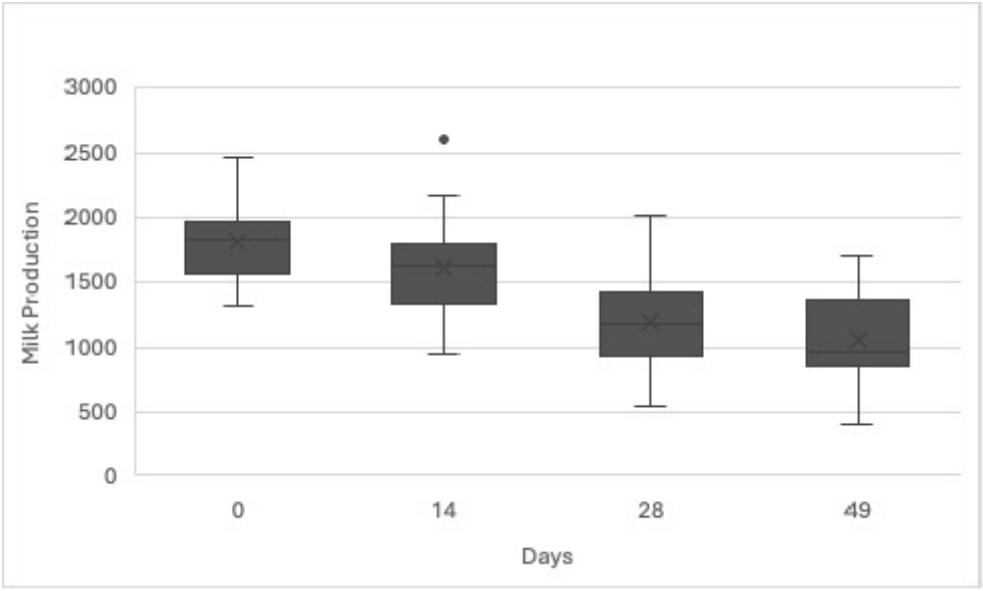


**Figure 3.** The differences between days of counting in the amount of milk production

In their study, Rotondi et al. (2018) [10] found that supplementation of dietary linseed and oregano increased goat milk's ether extract concentration but not protein content. Cosentino et al. (2021) [11] also found that fatty acids composition of goat milk was significantly influenced by the supplementation with oregano. Furthermore, Kalaitsidis et al. (2021) [12] found that dietary supplementation with oregano and thymus essential oils decreased lipid and protein oxidation in sheep milk, but did not affect fatty acid profile. Compared to cow and sheep milk, goat milk contains whey protein and has a structure that is different due to its insoluble and soluble protein and small fat globules, resulting in increased digestibility, especially for those with digestive disorders. This fact makes it imperative for further research into improving the quality characteristics of goat milk through the addition of essential oils of aromatic plants such as oregano.

## 4. Conclusions

The addition of organic oregano essential oil to goats at the late lactation, especially at a dose of 1ml per animal and day had a significant effect on milk production. But the effect of adding EO during the early period of lactation should be further investigated, as well as the effect on the

rumen microbiota, with *in vivo* tests, in order to explain any changes that may occur in milk yield and composition and the mechanisms of action.

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## References

1. OECD-FAO, Agricultural Outlook 2022-2031, https://www.oecd-ilibrary.org/agriculture-and-food/oecd-fao-agricultural-outlook-2022-2031_f1b0b29c-en
2. FAOSTAT 2024, https://www.fao.org/faostat/en/#data/QCL
3. Stefanaki, A., Cook, C. M., Lanaras, T., Kokkini, S., The Oregano plants of Chios Island (Greece): Essential oils of *Origanum onites* L. growing wild in different habitats, Industrial Crops and Products, 2016, 82, 107-113.
4. Giannenas, I., Skoufos, J., Giannakopoulos, C., Wiemann, M., Gortzi, O., Lalas, S., Kyriazakis, I., Effects of essential oils on milk production, milk composition, and rumen microbiota in Chios dairy ewes, Journal of Dairy Science, 2011, 94(11), 5569-5577.
5. Ozcinar, U., & Bayram, I., The influence of essential oils supplementation on yield and quality of sheep milk, Int J Sci Technol Res, 2021, 30-39.
6. Calsamiglia, S., Busquet, M., Cardozo, P. W., Castillejos, L., Ferret, A., Invited review: essential oils as modifiers of rumen microbial fermentation, Journal of dairy science, 2007, 90(6), 2580-2595.
7. Preuss, H. G., Echard, B., Enig, M., Brook I., Elliott, T. B., Minimum inhibitory concentrations of herbal essential oils and monolaurin for gram-positive and gram-negative bacteria, Cell Mol Biol., 2005, 272, 29–34.
8. Dutra, T. V., Castro, J. C., Menezes, Jéssica Lima, Ramos, T. R., Do Prado, I. N., Machinski, M., et al., Bioactivity of oregano (*Origanum vulgare*) essential oil against Alicyclobacillus spp., Ind. Crops Prod., 2019, 129, 345–349.
9. Zhou, R., Wu, J., Zhang, L., Liu, L., Casper, D. P., et al., Effects of oregano essential oil on the ruminal pH and microbial population of sheep. PLOS ONE, 2019, 14(5), e0217054.
10. Rotondi, P., Colonna, M. A., Marsico, G., Giannico, F., Ragni, M., Facciolongo, A. M., Dietary supplementation with oregano and linseed in Garganica suckling kids: effects on growth performances and meat quality, Pak. J. Zool., 2018, 50,1421–1433.
11. Cosentino, C., Colonna, M. A., Musto, M., Dimotta, A., Freschi, P., Tarricone, S., Paolino, R., Effects of dietary supplementation with extruded linseed and oregano in autochthonous goat breeds on the fatty acid profile of milk and quality of Padraccio cheese, Journal of Dairy Science, 2021, 104(2), 1445-1453.
12. Kalaitsidis, K., Sidiropoulou, E., Tsiftsoglou, O., Mourtzinos, I., Moschakis, T., Basdagianni, Z., Vasilopoulos S, Chatzigavriel S, Lazari D, Giannenas I., Effects of cornus and its mixture with oregano and thyme essential oils on dairy sheep performance and milk, yoghurt and cheese quality under heat stress, Animals, 2021, 11(4), 1063.