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# The Impact of Calf Rearing with Foster Cows on Calf Health, Welfare, and Veal Quality in Dairy Farms

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**Abstract:** This study assessed the impact of different calf rearing systems on calf health, behavior, meat quality, and oxidative stability. The study involved two groups of bull calves: conventionally penned calves (control, fed with use of automatic feeders) and calves reared alongside foster cows (experimental). The presence of foster cows was found to have a significant positive influence on calf health. Calves raised with foster cows experienced lower rates of diarrhea, delayed instances of coughing, and a reduced occurrence of rhinitis compared to conventionally reared calves. Behavioral observations revealed differences in sucking and licking behaviors between the two groups. Calves with foster cows displayed more consistent patterns of these behaviors, while conventionally reared calves exhibited greater variability. Additionally, the experimental group consistently achieved higher daily weight gains, suggesting the potential for larger and more valuable carcasses at slaughter. Importantly, there were no significant differences in the quality of veal between the two rearing groups. This included fatty acid composition, color attributes, and myoglobin levels, indicating consistent meat quality. In summary, this research highlights the advantages of rearing systems that prioritize calf health and behavior, emphasizing maternal care and natural behaviors. Such systems hold promise for improving calf welfare and enhancing the sustainability of the meat production industry. The integration of foster cows into dairy farming practices emerges as a practical and effective approach, particularly for the rearing of bull calves.

**Keywords:** calves; health; behavior; veal; oxidative stress; fatty acids



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## 1. Introduction

The development of biotech reproduction techniques, including semen preservation and artificial insemination, has increased the reproductive capacity of males [1]. Additionally, sexed semen is used to increase the likelihood of desired female calves being born in dairy farming [2–4]. However, this has led to intensive selection among males, reducing genetic diversity and increasing the risk of genetic diseases, as well as diminishing the value of production traits [5–11]. Furthermore, this selection model negatively impacts low-inbred functional traits like health, reproduction, and longevity [6,8,12], particularly noticeable on organic farms where feed differs significantly [13]. Despite the possibility of using sexed semen, it is rarely used due to the occurrence of reproductive problems in dairy cows associated with high milk yield [12,14,15] and poor herd management (mainly heat detection) [15,16]. As indicated by Frijters et al. [17], the causes of reduced fertility in cows with which sexed semen is used are due to lower sperm counts and sperm damage in the sexed semen Diskin et al. [18] and O'Callaghan et al. [19] pointed out that all focus only on the reproductive problems of cows and neglect the contribution of males to the fertilization process, and further remarked the need for male selection to improve ejaculate quality and semen preservation capabilities. According to Seidel and DeJarnette [4], the use of sexed semen in the USA approaches 30%. In a study by Januś et al. [20], it was indicated that the use of sexed semen is more effective in heifers and primiparous females, while conventional semen is most often used with multiparous females, due to the percentage of inseminations; which is why bulls are born in addition to heifers desired by breeders (as the typical sex distribution in newborn calves is 1:1) [21,22]. Due to the predominant share of dairy cows in Poland (more than 90% of females are dairy cows), male off are sent to be fattened to high weight values for beef production [23]. According to Solarczyk et al. [24] and Sakowski et al. [25], beef from Holstein–Friesian bulls has a significantly inferior nutritional value to dairy–meat hybrids and purebred individuals from meat breeds, therefore, an alternative to using Holstein–Friesian bulls may be to obtain veal [3].

As noted by Ngapo and Gariepy [26], the definition of veal varies widely and depends on the author and the author's country of origin. According to Resano et al. [27] and Domaradzki et al. [28], veal is the meat derived from the butchering of calf carcasses, and has specific qualities such as low fat content, a light color, tenderness, and a delicate taste due to the young age of the animals being slaughtered. According to Regulation 1254/99 of the Council of the European Union, in the European Union, a calf is considered to be an animal up to 300 kg in weight, with no permanent teeth [29]. Europeans regard veal as a delicacy and a dietary product, which is why its consumption is not popular everywhere. In Poland, about 20 t of veal was produced in 2010 and the average per capita consumption of this meat was 335 g [30]. According to Sans and de Fontguyon [31], veal accounts for about 20% of the meat from cattle in the EU, with over 33% of this total coming from dairy herds, where the majority, around 75%, is from male calves. Traditional rearing is conducted by leaving calves with their mothers after birth so that the calf takes colostrum straight from the cow's teat, and that will also stay with the mother during rearing and take milk directly from the mother ad libitum at least twice a day. This model is mainly used in beef cattle herds [31]. On the other hand, in modern calf rearing on dairy farms, the calves are almost immediately separated from their mothers after birth [22] so as not to cause either calves or cows the unnecessary stress associated with separation [32]. Calves in this type of system are fed from the very beginning using bottles and buckets fitted with teats, and, on large farms, using special vending machines for feeding colostrum and milk, or conventional milk-substitute formulae, which provide the necessary nutrients while also increasing farmers' profits, as the milk can then be sold [33]. Some veterinarians even believe that by weaning calves quickly, breeders will provide better rearing conditions for their calves [34]. As reported by Haskell [22], some of the calves destined for veal procurement are transported at about eight days of age to special rearing houses where they are housed until slaughter, i.e., 8–10 months of age. These preparations are not used on organic farms, where only whole milk is used in rearing [35]. In this system, it would therefore be most cost-effective to keep the calves with suckler cows, which is a natural system in which the calf can take milk directly from the cow, which can further reduce the labor involved in milking and feeding the calves [36]. This is seen by many consumers as the most appropriate and most important system for improving animal welfare [37–41].

The rearing of calves in dairy herds is a huge challenge, which is why various practices are used on farms to obtain the best possible results. These activities are focused primarily on the rearing of healthy females, which in the future will be used for the renovation of the herd, while any bulls that are born are quite a problem because they do not represent valuable breeding material in these herds [21,42]. Practices related to the rearing of male animals vary. Many farmers decide to euthanize males immediately after birth; some farmers decide to sell their bulls in the first week of life, after which the animals are slaughtered for hide, rennet, and meat for pet animals. Still, other farmers sell these males to special rearing facilities where the animals are destined to become veal or beef [22,42–44]. With this last choice, the length of time animals are kept, and thus the type of meat obtained, depends largely on the preferences of the consumers in a given country. In Poland, due to the rather low consumption of veal, bulls of the Holstein–Friesian breed are sent for fattening to reach high weight values, which, as indicated by Solarczyk et al. [24] and Sakowski et al. [25], is not the best solution due to the resulting rather low quality meat. In dairy herds, regardless of sex, the most common practice is to wean calves from their mothers almost immediately [45], which can be for various reasons: from a desire to better care for the calf, including the administration of the right amount and the best quality colostrum (i.e., to ensure adequate transfer of passive immunity); to reduce the stress associated with weaning calves from their mothers; to reduce the incidence of disease entities; and—what is in truth the most important factor—to be able to reduce the rearing costs associated with administering milk replacers and the sale of whole milk from cows, as well as the comfort to take care of animal handlers [32]. In the case of male calves, very often breeders do not pay attention to the quality of colostrum or the timing of its administration, due to which their passive immunity is not at a high level [46,47]. Recently, the attention of more and more consumers has been drawn to the welfare of animals; therefore, they are very often surprised by the practices used on dairy farms imagining that calves' long-term contact with their mothers is the most natural process, and which typically allows proper behavior [48–51]. For weaning older calves, there are also different models: single-stage weaning, which involves completely separating the calves from the mothers; and two-stage weaning, which involves putting on special nose-flaps. According to Valente et al., by far the best way to wean older calves from their mothers is the single-stage weaning, which is less stressful [52].

The quality of veal is the result of a complex interplay among numerous factors, such as nutrition, age at slaughter, exercise, stress levels, rearing conditions, genetics, carcass handling, calf health, and consumer preferences [41]. Variations in rearing systems can influence these factors, ultimately shaping the characteristics and quality of veal meat. In summary, a profound scientific understanding of the natural behaviors, anatomy, and physiology of cows and calves is essential for informed decision-making in calf rearing, whether it is mother-bonded, fostered, or motherless calf rearing. This knowledge is critical for ensuring calf health, welfare, and overall well-being, regardless of the chosen rearing method. The objective of the experiment was to investigate how different rearing methods affect calf behavior, calf health, and the quality of veal produced.

## 2. Materials and Methods

The study was conducted on an organic dairy farm in Wyczechowo (PL), utilizing two groups of bull calves, each comprising 5 calves of the same age and origin. The experiment was replicated three times, resulting in a total of 30 calves per group. The farm's breeding practices adhered to the guidelines outlined in Regulation (EU) 2018/848 of the European Parliament and the Council, dated 30 May 2018, pertaining to organic production and the labeling of organic products [53]. It is essential to recognize that there are notable distinctions between organic animal husbandry and conventional animal husbandry. These distinctions encompass the use of allopathic medicinal products, the potential utilization of milk replacers for calf rearing, as well as the approaches employed for managing pain-inducing procedures. Of significance is the observation that organic systems typically provide animals with increased space within livestock buildings, constituting a noteworthy difference when compared to conventional systems. The control group was reared conventionally using automatic feeders, with each calf receiving approximately 1000 kg of milk over a 6-month period, in addition to access to hay. The milk was provided twice a day and came from cows kept on the farm. The experimental group, on the other hand, had permanent access to two foster cows and hay. The calf's diet was meticulously calculated to comprise 15–20% of their body weight in whole milk. This parameter was rigorously assessed and maintained consistently across both experimental groups for precise nutritional monitoring.

The selection of foster cows involved an assessment of specific criteria to ensure an optimal calf rearing environment. Priority was given to cows with established strong maternal instincts and a successful history of mothering. Additionally, the health status of the chosen cows was a paramount consideration, with a requirement for them to be in good health and free from contagious diseases. The study's results did not reveal any significant differences in crucial milk performance parameters or the cytological quality of milk between foster cows and conventionally milked cows on the farm. Specifically, the milk sourced from both categories consistently displayed bacterial levels below the threshold of 100,000 CFU and somatic cell counts below 200,000 cells per milliliter.

Calf weighing was conducted using the CalmScale system (Jantar Sp. z o.o., Bielsko-Biała, Polska), which is designed to minimize stress during the process. The system is placed in the cattle's watering area and employs RFID tags and antennas for precise identification. Weight data, along with other relevant information, is recorded and made available for analysis after processing. Average daily gain (ADG) was calculated by taking the weight difference from day 0 (pre-treatment weight) and dividing it by the number of days since day 0, providing a crucial metric for assessing calf growth.

After the calves reached the appropriate age (6 months), they were slaughtered, and their carcasses were cooled for 24 h at 2–4 °C to facilitate proper meat preservation. Following the cooling period, 300 g samples of semimembranosus muscle were collected from each calf parallel to the muscle axis.

The daily health assessment of the animals was conducted by a veterinarian, who documented all incidents, encompassing episodes of diarrhea, occurrences of coughing, and instances of rhinitis. In tandem with these observations, standard preventive measures targeting contagious viral diseases and parasitic infections were implemented. In conclusion, the paramount strategy for curtailing the transmission of Cryptosporidia and Coccidia in calves revolves around the unwavering commitment to hygiene protocols, which includes the routine disinfection of all surfaces that have direct contact with the calves.

The behavioral data were collected as averages from 5-h observation periods conducted monthly during the first 6 months of a calf's life. In the ethogram-based analysis of calf behavior, behaviors were initially categorized into three main categories: active, resting, and abnormal (Table 1). Active behaviors involved movement, resting behaviors indicated immobility, and abnormal behaviors included actions like calves sucking or licking other calves (mouth, ears, navel, tail, and scrotal) and sucking or licking objects within their pens. These abnormal behaviors were seen as deviations from typical calf behavior patterns and could potentially indicate issues like stress or boredom. This systematic observation approach allowed for a comprehensive understanding of the behavioral patterns and interactions among the calves during their early development. Behaviors were categorized into specific points, with each behavior recorded as a total frequency. This total frequency encompassed the sum of behaviors like sucking or licking objects and the sum of behaviors involving sucking or licking other calves per hour.

**Table 1.** Ethogram and categorization of behaviors.

| Category | Behavior | Description |
|---|---|---|
| Active behaviors: behaviors involving movement | Locomotion<br>Play (alone)<br>Smell | Walking or running.<br>Manipulating non-food object.<br>Smelling the ground or an object. |
| Resting behaviors: behaviors involving little to no movement | Lying down<br>Defecate/Urinate<br>Groom<br>Social rest | Lying down with very little movement, whether asleep or awake.<br>Categorized as resting because movement behavior must be paused.<br>Scratching, gnawing, or licking oneself.<br>Lying while in physical contact with at least one other calf. |
| Abnormal Behavior | Sucking or licking | Sucking or licking other calf's (mouth, ears, navel, tail, and scrotal).<br>Sucking or licking objects in pens. |

### 2.1. Fatty Acid Analysis

Intramuscular fat was extracted from 10 g of muscle using a mixture of chloroform and methanol in a 2:1 (*v*:*v*) ratio. The fatty acids were then converted into fatty acid methyl esters (FAME) through a base-catalyzed transesterification process using sodium methoxide in methanol. To standardize the measurements, methyl nonadecanoate (C19:0) was used as the internal reference compound. The fatty acids were separated using a gas chromatograph (model TRACE GC; Thermo Finnigan, Milan, Italy), which employed a high-polar fused silica capillary column measuring 100 m in length, with a diameter of 25 mm and a film thickness of 0.25 µm (SP. 24056; Supelco Inc., Bellefonte, PA, USA). Identification of the FAME compounds was achieved using a flame ionization detector (FID). The gas chromatography conditions and the process for identifying FAME compounds followed the protocol as outlined by Natalello et al. [54].

### 2.2. Meat Oxidative Stability

Oxidative stability assessment of fresh meat followed a protocol described by Natalello et al. [55]. Three 2 cm-thick meat slices were prepared from each Longissimus thoracis et lumborum (LTL) muscle sample and stored in polystyrene trays wrapped with three layers of domestic cling film. The storage took place in the dark at 4 °C for different durations: zero days (after 2 h of blooming), three days, and seven days. After each storage period, one of the three slices was used to measure color parameters. Color stability assessment utilized a Minolta CM 2022 spectrophotometer, configured in the specular components excluded (SCE) mode. Measurements were performed with illuminant A and a 10° standard observer. Three non-overlapping measurements were taken on the meat's surface, and the mean value was calculated. Color descriptors, including L* (lightness), a* (redness), b* (yellowness), C (saturation), and hab (hue angle), were recorded in the CIE L* a* b* color space.

Lipid oxidation analysis involved measuring the concentration of 2-thiobarbituric acid reactive substances (TBARS) at the conclusion of each storage period. The method was adapted from Natalello et al. [55]. Meat samples (2.5 g) were homogenized with 12.5 mL of distilled water using a Heidolph Diax 900 tissue homogenizer (Heidolph Elektro GmbH & Co. KG, Kelheim, Germany), placed in a water/ice bath during homogenization. Subsequently, 12.5 mL of 10% (*w*/*v*) trichloroacetic acid (TCA) was added to precipitate proteins, and the samples were then filtered. The clear filtrate (4 mL) was mixed with 1 mL of 0.06 M aqueous thiobarbituric acid in Pyrex glass tubes. Tubes were incubated in a water bath at 80 °C for 90 min, and absorbance was read at 532 nm using a Shimadzu UV/vis spectrophotometer (UV-1601). Concentration of malondialdehyde (MDA) in each sample was determined using a calibration curve prepared with TEP (1,1,3,3-tetraethoxypropane) in distilled water at concentrations ranging from 5 to 65 nmol/4 mL. Results were expressed as milligrams of MDA per kilogram of meat.

### 2.3. Myoglobin Analysis

Myoglobin concentration was determined following a method described by Krzywicki [56], with some modifications. Briefly, 2 g of muscle were homogenized using a Heidolph Diax 900 tissue homogenizer operating at 9500 rpm with a phosphate buffer. The homogenized samples were then subjected to centrifugation at 6800× *g* at 4 °C for 15 min and subsequently filtered through Whatman 541 paper. The filtered supernatant was scanned using a UV/VIS spectrophotometer (UV-1601; Shimadzu Co., Milan, Italy), and the absorbance at 525 nm was measured. Myoglobin concentration was calculated based on these absorbance measurements and expressed as milligrams per gram (mg/g) of fresh tissue.

### 2.4. Statistical Model

The experimental data from the evaluation of the calves' fattening performance were analyzed using the GLM Repeated Measures Procedure by SAS, ver.9.0 and following statistical model:

$$y_{ijk} = \mu + T_i + R_j + T \times R_{ij} + e_{ijk}$$

where $y_{ijk}$ is the investigated trait; μ is the overall mean; $T_i$ is the fixed effect of the i-th experimental group where 1 is the calves reared in a pen; and 2 is the calves kept with suckler cows. $R_j$ is the fixed effect of the j-th replicated group of the experiment; $G \times R_{ij}$ is the fixed effect of the interaction between group and replicated group; and $e_{ijk}$ is the random error.

The fat, fatty acid, and myoglobin content was estimated using one-way analysis of variance and following the statistical model:

$$y_{ij} = \mu + T_i + e_{ij}$$

where $y_{ij}$ is the investigated trait; μ is the overall mean; $T_i$ is the effect of the treatment group (i = "in pen"; "foster cow"); and $e_{ij}$ is the residual error.

To assess the oxidative stability data (color and lipid oxidation over time of storage) the MIXED Procedure by SAS, ver. 9.0 was used following the statistical model:

$$Y_{ijkl} = \mu + T_i + D_j + I_k\ (T) + (T \times D)_{ij} + e_{ijkl}$$

where $y_{ijkl}$ is the observation; μ is the overall mean; $T_i$ is the fixed effect of the treatment group (i = "in pen"; "foster cow"); $D_j$ is the fixed effect of the day of storage (j= 0, 3, 7 days for color and 0. 7 for lipid oxidation); $I_k(T)$ is the random effect of the individual animal nested within the dietary treatment; $(T \times D)_{ij}$ is the interaction between treatment and day of storage; and $e_{ijkl}$ is the residual error. Differences between means were assessed using Tukey's adjustment for multiple comparisons [57].

Chi-square analysis was employed to evaluate the disease status (diseased or not diseased) in relation to the group assignment (control group vs. experimental group).

## 3. Results

### *3.1. Animal Behavior*

Figures 1 and 2 show the results of the calves' behavior during the experiment.

The behavioral data were obtained as averages from a 5-h observation period conducted at monthly intervals during the first 6 months of a calf's life and included recording the sum of instances in which the calves engaged in sucking/licking per hour. For the control group (calves in pen), the calves sucked or licked various objects most frequently during the fourth month of life (69 times) and least frequently during the third month (7 times). For the experimental group (calves with foster cows), they sucked or licked objects most frequently during the sixth month of the experiment (51 times) and least frequently during the second month of the experiment (9 times).

Figure 2 shows the results for the sum of sucking or licking other calves during a one-hour period. The calves in the pen group sucked or licked a total of 187 times, while the calves with the foster cows sucked or licked 113 times, which was 74 times fewer than the control group. The calves in the pen group sucked or licked other calves most frequently during the fourth month of the experiment (70 times) and least frequently during the second month of the experiment (20 times). In the third month of the experiment, no such behavior was observed in the control group. In the case of the experimental group, the calves sucked or licked another individual most frequently in the sixth month of the experiment (44 times) and least frequently in the first month of the experiment (2 times).

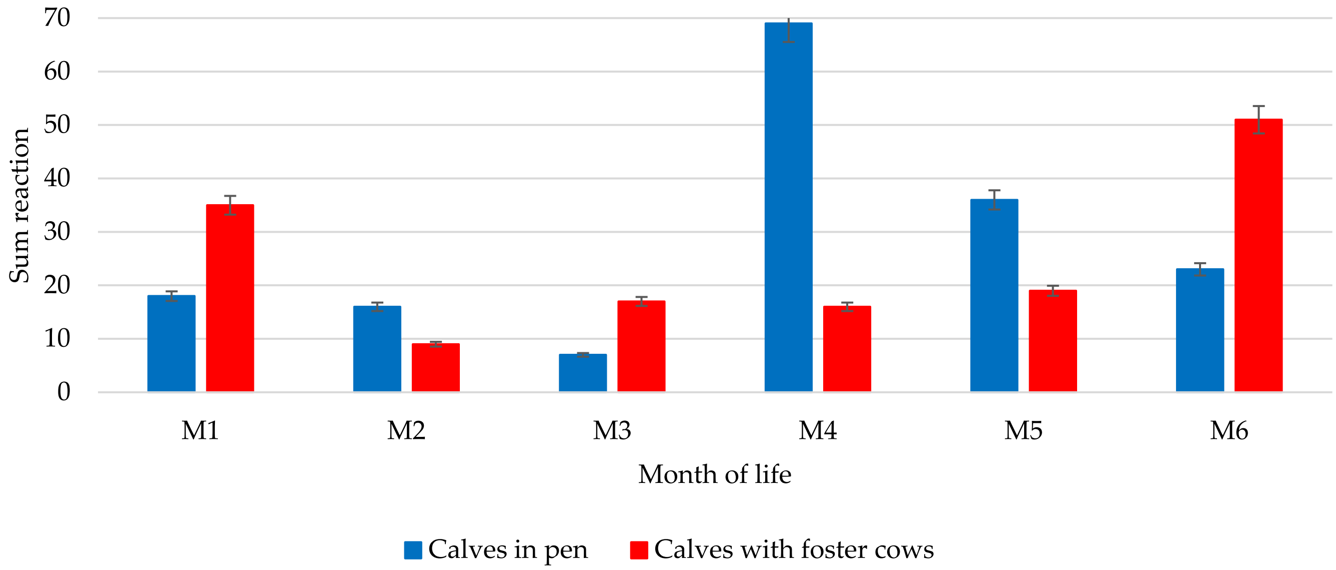


**Figure 1.** Behavioral observations, conducted at monthly intervals during the first 6 months of a calf's life, included recording the sum of instances in which the calves engaged in sucking/licking things per hour.

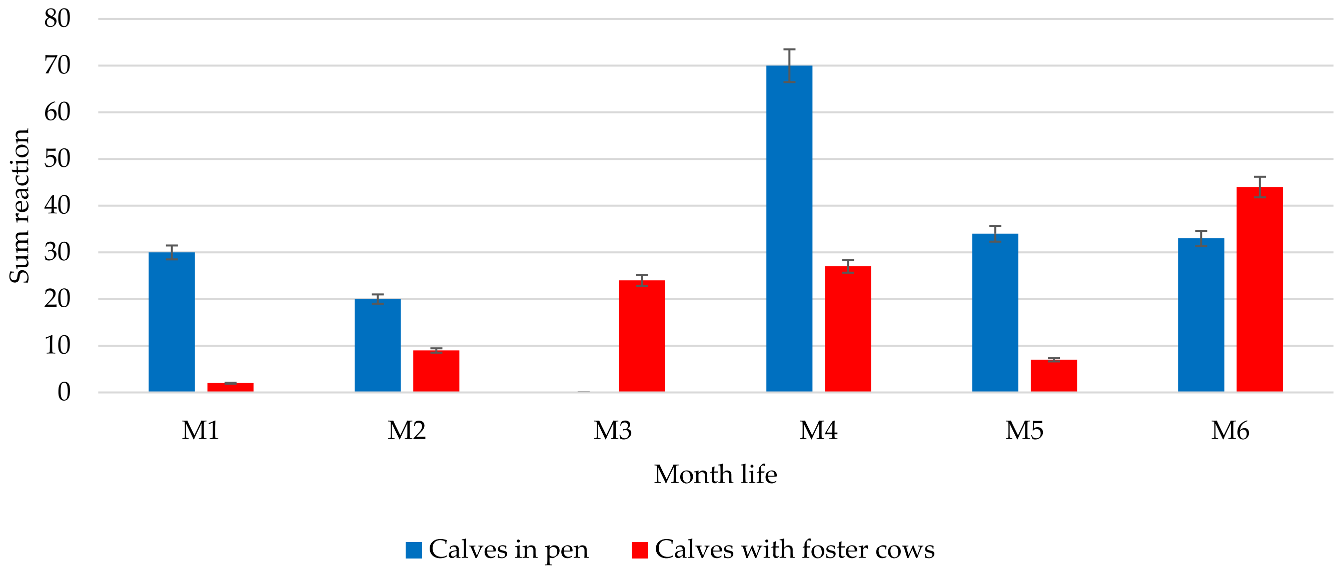


**Figure 2.** Behavioral observations, conducted at monthly intervals during the first 6 months of a calf's life, included recording the sum of instances in which the calves engaged in sucking/licking another calf per hour.

### 3.2. Animal Health

Figures 3–5 show the results for animal health.

Figure 3 shows the results for the occurrence of diarrhea. Diarrhea occurred in calves during the first four months of the experiment. In the calves in pen group, diarrhea occurred in six animals during the first month of the experiment, while in the calves with foster cows group it occurred in only one calf, and this was the only occurrence of diarrhea in this group. In the case of the control group, diarrhea was still occurring in the second month of the experiment in four individuals, in the third month of the experiment in two individuals, and in the fourth month of the experiment in one individual.

Figure 4 shows the incidence of coughing in the experimental calves. According to the collected information, coughing occurred in both the control and experimental groups. In the calves in pen group, it occurred in the first month of the experiment in two calves, in the third month in three calves, and in the fifth month also in three calves. Coughing in the calves with foster cows group did not occur until the sixth month of the experiment and only affected one individual.

Figure 5 shows the results for the incidence of rhinitis. The observations showed that rhinitis only occurred in the calves in pen group during the first month in one individual, during the second month in three individuals, during the fourth month also in three individuals, and during the sixth month in one individual. No such observation was recorded in the calves with foster cows group.

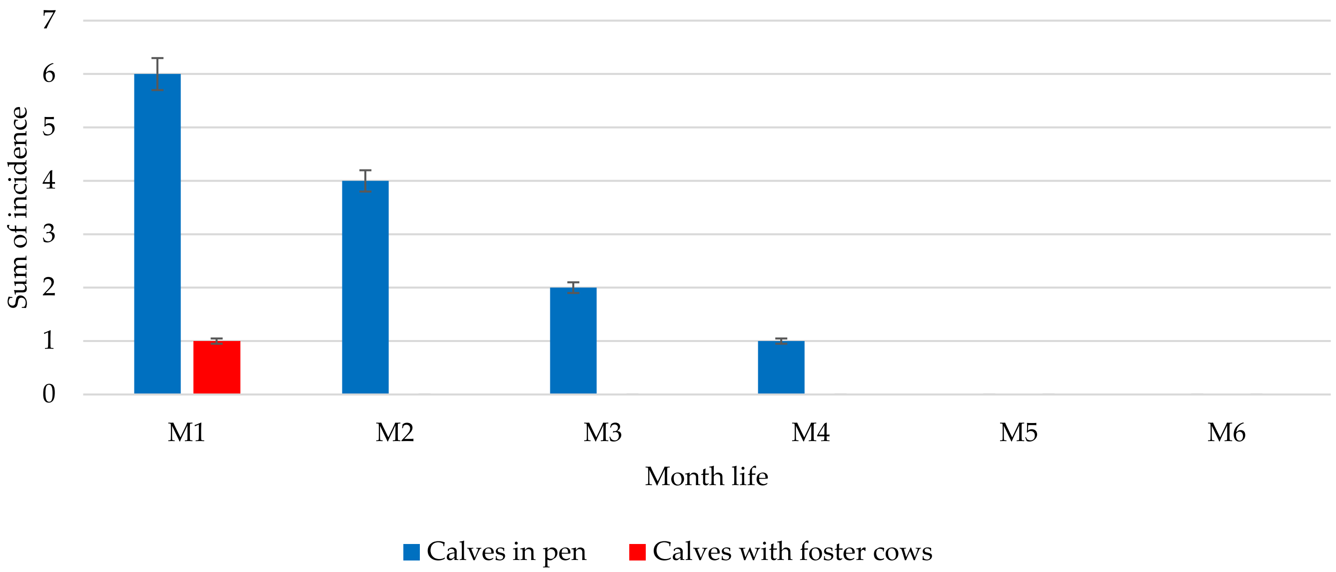


**Figure 3.** Incidence of diarrhea in calves.

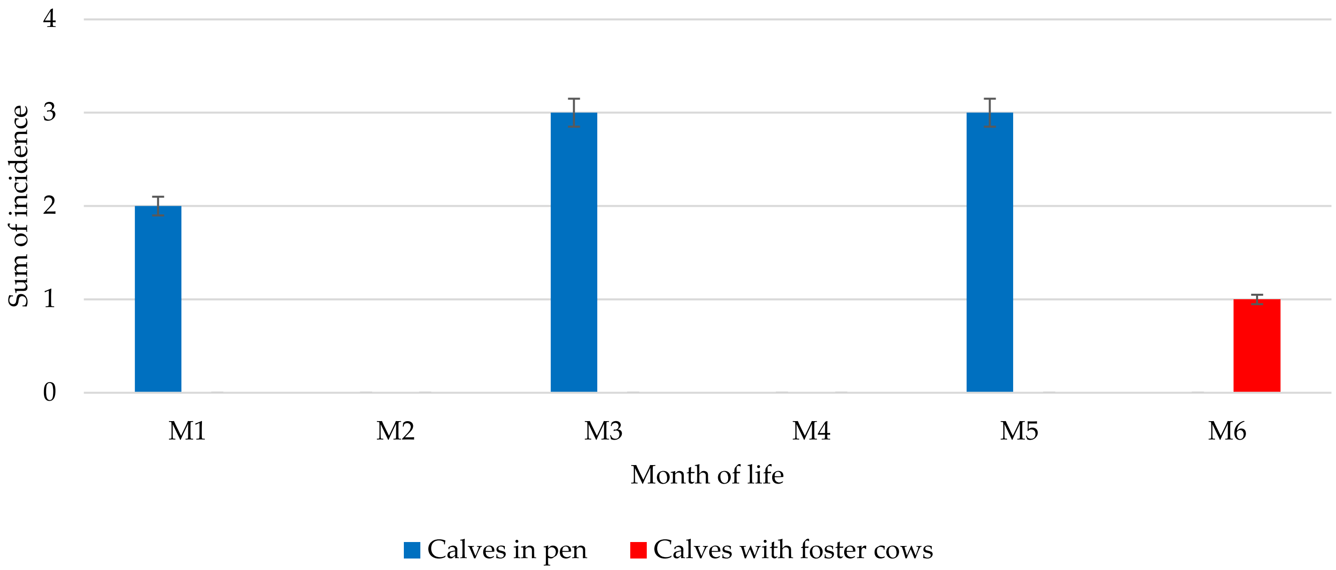


**Figure 4.** Incidence of coughing in calves.

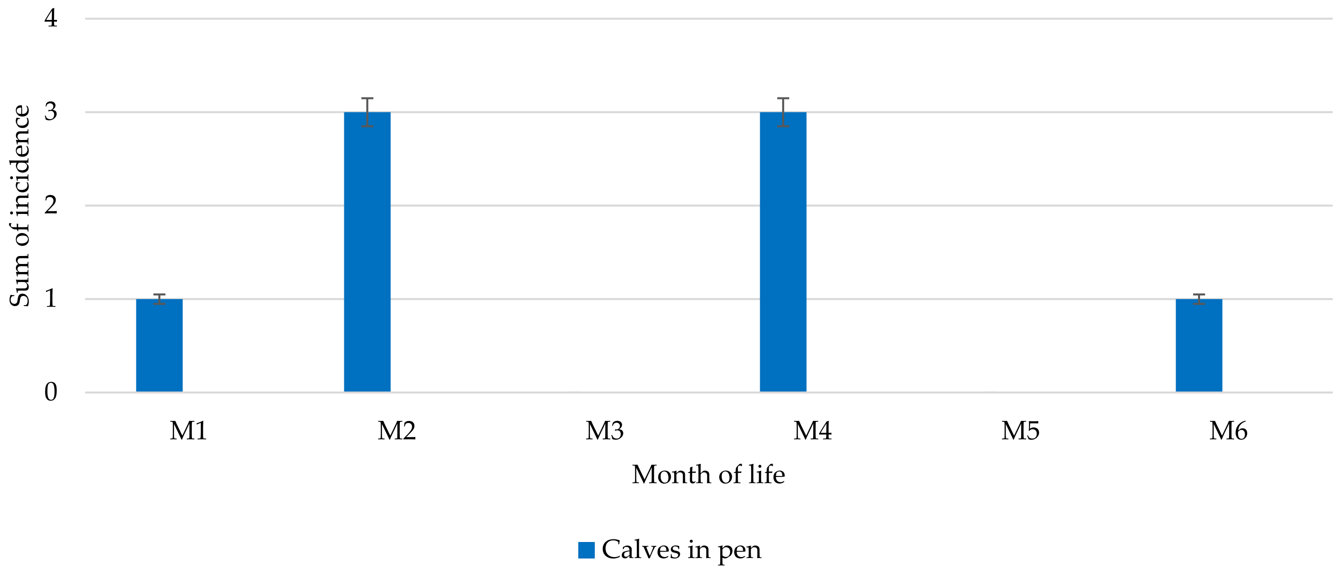


**Figure 5.** Occurrence of rhinitis.

### *3.3. Animal Body Weight*

Figures 6 and 7 show the result body weight.

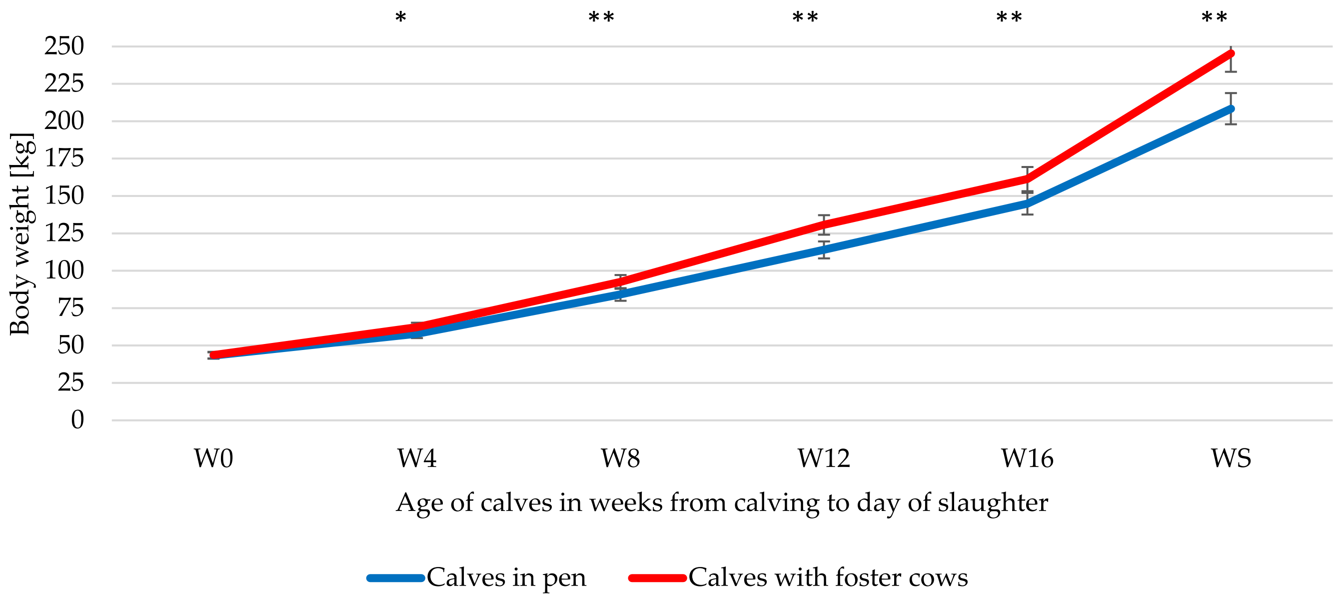


**Figure 6.** Changes in body weight. * $p \leq 0.05$, ** $p \leq 0.01$.

The body weight results are shown in Figure 6. The body weight measurements were taken six times during the experiment at four-week intervals from the day of birth until the day the calves were slaughtered.

The average body weight of the calves on the day of birth was similar for both groups and was 43.36 kg for the control group, in which the calves were fed using a calf feeder. In the experimental group, where the calves were fed by sucklers, the weight of the calves was 43.64 kg. The difference between the groups was −0.28 kg (control–experimental group). The second calf weight measurement was taken at week four of calf life. The average body weight of the calves in the calves in pen group was 58.76 kg an increase of 15.4 kg, while in the calves with foster cows group it was 62.21 kg, an increase of 18.58 kg: in percentage terms. This was an increase of 33.44% for the calves in pen group and 42.58% for the calves with foster cows group, compared to birth weight. The next average body weight measurement was taken at week eight of the experiment. The animals in the calves in pen group had reached a weight of 84.21 kg, an increase of 40.85 kg (94.21%) compared to the initial weight. In the calves with foster cows group, the weight of the animals for the third measurement was 92.57 kg, an increase of 48.93 kg compared to the initial weight, indicating an increase of 112.12%. The difference between the weight of the calves in the calves in pen group to that of the calves in the calves with foster cows group was −8.36 kg ($p \leq 0.05$). The fourth weight measurement was taken at 12 weeks of calf age. The average body weight in the calves in pen group was 114.00 kg an increase of 70.64 kg (162.92%) compared to the initial weight. The calves in the calves with foster cows group had reached a weight of 130.71 kg an increase of 87.07 kg (199.52%). The difference in the weight of the control compared to the calves with foster cows group was −16.71 kg ($p \leq 0.01$). The next weight measurement was taken at week 16 of the experiment; the calves in the calves in pen group had reached a weight of 144.86 kg, an increase of 101.5 kg (234.09%). The weight of the calves in the calves with foster cows group was 161.36 kg, an increase of 117.72 kg (269.75%). The difference in the average body weight of the control group compared to the experimental group was -16.5 kg for this measurement ($p \leq 0.01$). The last weight measurement for the calves was taken on the day they were slaughtered. The calves in the calves in pen group had reached a weight of 208.43 kg, and the weight of these animals had increased by 165.07 kg (380.43%). Calves in the calves with foster cows group had reached a weight of 245.36 kg, and their weight increased by 201.72 kg (462.24%) compared to the calves' birth weight. On the day of slaughter, the weight of the calves in the control group was 36.93 kg ($p \leq 0.01$) lower than that of the calves in the experimental group. On the basis of the obtained body weight results, it was possible to estimate the daily gains, which are shown in Figure 7.

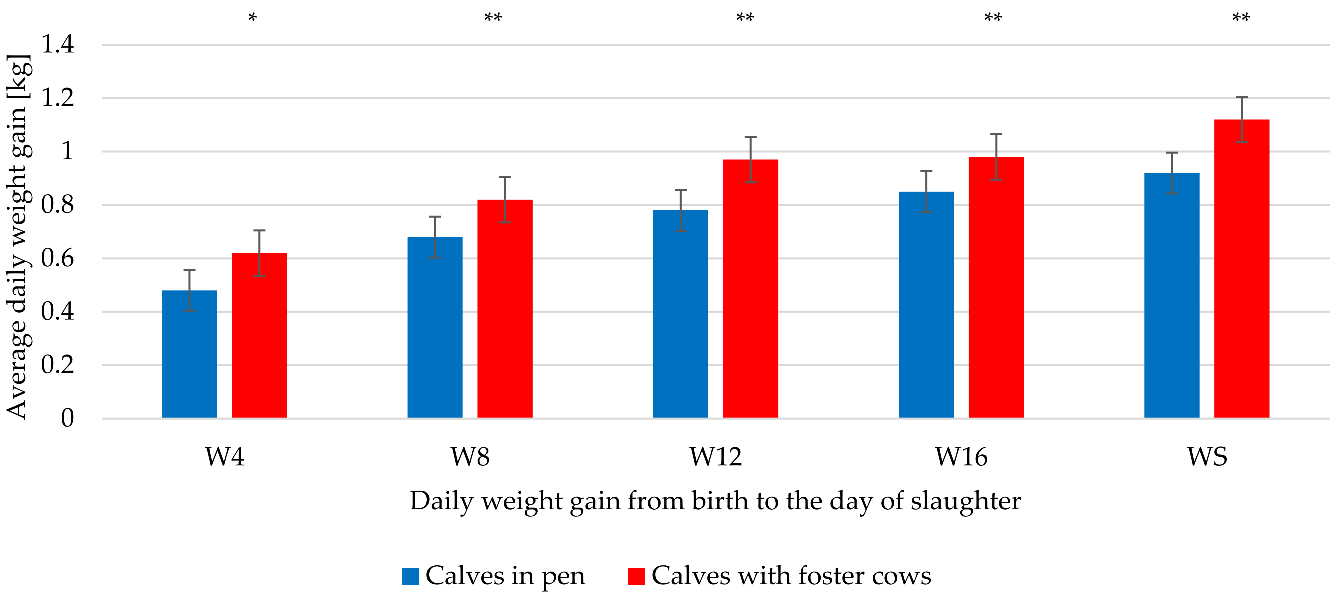


**Figure 7.** Daily weight gain from birth to the day of slaughter. * $p \leq 0.05$, ** $p \leq 0.01$.

In Figure 7, the daily gains were determined using the changes in body weight between individual weight measurements, with the first weight growth being determined in week four of the experiment. From the very beginning of the experiment there was an evident difference between the daily gains of the calves from each group, with the calves with foster cows group's weights being higher. In week 4, the daily difference was −0.14 kg ($p \leq 0.05$), in week 8 the daily difference was the same −0.14 kg ($p \leq 0.01$), in week 12 it was −0.19 kg ($p \leq 0.01$), in week 16 it was −0.13 kg ($p \leq 0.01$), while on the day of slaughter the daily difference was −0.20 kg ($p \leq 0.01$). The results confirm the faster growth rate of calves kept with sucklers and the possibility of obtaining higher animal weights on the day of slaughter.

### *3.4. Analysis of Veal*

#### 3.4.1. Quality of Veal

Basic composition is of great importance in assessing the nutritional value of the meat, the results of which are shown in Table 2. In this experiment, using muscle tissue from the calves in the control group, the protein content was found to be 31.24 g, and was 2.16 g lower ($p \leq 0.01$) than that of the animals in the experimental group, where it was 33.4 g.

**Table 2.** The basic composition of the veal.

| | **Calves in Pen** | | **Calves with Foster Cows** | | ***p*-Value** |
|---|---|---|---|---|---|
| | **LSM** | **SEM** | **LSM** | **SEM** | |
| Protein | 31.24 | 0.127 | 33.4 | 0.225 | 0.01 |
| Fat | 2.01 | 0.042 | 1.88 | 0.099 | 0.05 |
| IMF | 1.84 | 0.741 | 1.47 | 0.740 | 0.01 |

LSM—least square means. SEM—standard error of LSM. IMF—intramuscular fat.

The second parameter assessed was the fat content, which was 0.13 g lower in the muscle tissue of the animals in the calves with foster cows group (compared to the calves in pen group) and amounted to 1.88 g, while in the calves in pen group it was 2.01 g ($p \leq 0.05$). Concerning the adipose fraction, we can distinguish between perimuscular fat and intramuscular fat. In the results obtained from the muscle tissue, the intramuscular fat content was also higher in calves from the control group, the difference being 0.37 g ($p \leq 0.01$).

The next analysis concerned the determination of the fatty acid profiles. Table 3 summarizes the results for saturated fatty acids, Table 4 for monounsaturated fatty acids, and Table 5 for polyunsaturated fatty acids.

**Table 3.** Profile of saturated fatty acids.

| **Component (g/100 g of Fat)** | **Calves in Pen** | | **Calves with Foster Cows** | | ***p*-Value** |
|---|---|---|---|---|---|
| | **LSM** | **SEM** | **LSM** | **SEM** | |
| C10:0 | 0.04 | 0.010 | 0.05 | 0.014 | 0.000 |
| C12:0 | 0.13 | 0.040 | 0.20 | 0.067 | 0.000 |
| C13:0 | 0.03 | 0.013 | 0.04 | 0.014 | 0.009 |
| C14:0 iso | 0.04 | 0.010 | 0.06 | 0.018 | 0.000 |
| C14:0 | 3.26 | 0.725 | 3.96 | 1.131 | 0.001 |
| C15:0 iso | 0.11 | 0.023 | 0.15 | 0.043 | 0.000 |
| C15:0 anteiso | 0.16 | 0.059 | 0.23 | 0.062 | 0.000 |
| C15:0 | 0.41 | 0.125 | 0.61 | 0.142 | 0.000 |
| C16:0 iso | 0.18 | 0.035 | 0.20 | 0.046 | 0.010 |
| C16:0 | 21.86 | 1.779 | 24.66 | 3.129 | 0.000 |
| C17:0 iso | 0.29 | 0.049 | 0.34 | 0.051 | 0.000 |
| C17:0 anteiso | 0.39 | 0.076 | 0.44 | 0.094 | 0.003 |
| C17:0 | 0.84 | 0.120 | 0.94 | 0.197 | 0.002 |
| C18:0 | 11.27 | 1.748 | 12.58 | 2.242 | 0.001 |
| C20:0 | 0.10 | 0.025 | 0.13 | 0.036 | 0.000 |
| C22:0 | 0.01 | 0.015 | 0.04 | 0.034 | 0.000 |
| C24:0 | 0.53 | 0.205 | 0.78 | 0.428 | 0.000 |
| SFA | 37.15 | 3.614 | 42.39 | 5.142 | 0.000 |

LSM—least square means. SEM—standard error of LSM. SFA—saturated fatty acids.

In this experiment, the 17 saturated fatty acids and the sum of the content of these fatty acids were determined. The values of all fatty acids obtained were higher for the calves with foster cows group than for the calves in pen group ($p \leq 0.01$). Among the saturated fatty acids determined in this experiment, C16:0 had the highest content, with a level of 21.86 g for the calves in pen group and 24.66 g for the calves with foster cows group (2.8 g higher compared to the calves in pen group). The second most abundant acid was C18:0, whose level in the calves in pen group was 11.27 g, while in the calves with foster cows group it was 12.58 g (1.31 g higher). The next most abundant fatty acid was C14:0, whose content in the calves in pen group was 3.26 g, while in the calves with foster cows group it was 3.96 g (0.70 g higher). The value of the other fatty acids was below 1 g.

**Table 4.** Profile of monounsaturated fatty acids.

| Component (g/100 g of Fat) | Calves in Pen | | Calves with Foster Cows | | *p*-Value |
|---|---|---|---|---|---|
| | LSM | SEM | LSM | SEM | |
| C14:1 *cis9* | 0.79 | 0.227 | 0.72 | 0.161 | 0.025 |
| C16:1 *trans9* | 0.05 | 0.012 | 0.05 | 0.009 | 0.508 |
| C16:1 *cis7* | 0.26 | 0.042 | 0.27 | 0.065 | 0.617 |
| C16:1 *cis9* | 3.17 | 0.613 | 2.85 | 0.599 | 0.010 |
| C18:1 t6+t7+t8 | 0.07 | 0.033 | 0.06 | 0.026 | 0.122 |
| C18:1 *trans9* | 0.20 | 0.036 | 0.19 | 0.036 | 0.030 |
| C18:1 *trans10* | 0.20 | 0.183 | 0.08 | 0.030 | <0.001 |
| C18:1 *trans11* | 0.40 | 0.134 | 0.48 | 0.162 | 0.014 |
| C18:1 *cis6* | 0.35 | 0.103 | 0.37 | 0.089 | 0.361 |
| C18:1 *cis9* | 28.69 | 3.671 | 24.04 | 2.811 | <0.001 |
| C18:1 *cis12* | 0.20 | 0.013 | 0.20 | 0.069 | 0.007 |
| C18:1 *cis13* | 0.16 | 0.039 | 0.16 | 0.041 | 0.057 |
| C20:1 *cis11* | 0.13 | 0.023 | 0.14 | 0.024 | 0.013 |
| C24:1 *cis9* | 0.12 | 0.041 | 0.15 | 0.075 | 0.002 |
| MUFA | 36.35 | 4.378 | 31.15 | 3.047 | <0.001 |

LSM—least square means. SEM—standard error of LSM. MUFA—monounsaturated fatty acids.

**Table 5.** Profile of polyunsaturated fatty acids.

| Component (g/100 g of Fat) | Calves in Pen | | Calves with Foster Cows | | *p*-Value |
|---|---|---|---|---|---|
| | LSM | SEM | LSM | SEM | |
| C18:2 *cis9cis12* | 5.23 | 1.601 | 5.75 | 2.742 | 0.822 |
| C18:3 *cis6.9.12* | 0.03 | 0.018 | 0.04 | 0.0271 | 0.166 |
| C18:3 *cis9,12,15* | 0.72 | 0.162 | 0.91 | 0.298 | 0.269 |
| C18:2 *cis9 trans11* | 0.24 | 0.054 | 0.19 | 0.037 | 0.006 |
| C20:2 *cis11,14* | 0.05 | 0.025 | 0.06 | 0.037 | 0.006 |
| C20:3 *n-6* | 0.44 | 0.164 | 0.56 | 0.301 | 0.010 |
| C20:4 *n-6* | 2.07 | 0.752 | 2.65 | 1.478 | 0.008 |
| C22:4 *n-6* | 0.02 | 0.017 | 0.03 | 0.025 | 0.002 |
| C22:5 *n-3* | 0.16 | 0.082 | 0.17 | 0.093 | 0.512 |
| PUFA | 9.67 | 2.989 | 11.32 | 5.371 | 0.033 |
| n-6 PUFA | 8.55 | 2.798 | 10.06 | 5.030 | 0.037 |
| n-3 PUFA | 0.88 | 0.227 | 1.07 | 0.384 | 0.001 |
| n-6/n-3 | 9.52 | 1.070 | 8.95 | 1.876 | 0.029 |

LSM—least square means. SEM—standard error of LSM. PUFA—polyunsaturated fatty acids.

The total content of the SFA family of fatty acids in the calves in pen group was 37.15 g, while in the calves with foster cows group it was 42.39 g, making it 5.24 g higher than the calves in pen group ($p \leq 0.01$).

The results for the monounsaturated fatty acid content are summarized in Table 4. Among these fatty acids, the highest content was oleic acid (C18:1). The content of this acid in the calves in pen group was 28.69 g, while in the calves with foster cows group it was 24.04, with the difference being as much as −4.65 ($p \leq 0.01$). In this group, the second most abundant fatty acid was C16:1 cis 9, with a content of 3.17 g in the calves in pen group and 2.85 g in the calves with foster cows group (0.32 g lower) ($p \leq 0.01$). The content of the other acids of the MUFA family was less than 1 g.

The total content of MUFA acids for the calves in pen group was 36.35 g and was at a higher level (5.2 g ($p \leq 0.01$)) than the calves with foster cows group where it was 31.15 g.

The polyunsaturated fatty acid content is presented in Table 5. C18:2 cis9 cis12 linoleic acid was characterized by the highest content in this group of acids. The value of this fatty acid in the calves in pen group was 5.23 g, while in the calves with foster cows group it was 5.75 g, 0.52 g higher ($p = 0.822$). The second most abundant fatty acid was C20:4 n-6 arachidonic acid, whose content in the calves in pen group was 2.07 g, while in the calves with foster cows group it was 2.65 g, 0.58 g higher than in the calves in pen group ($p \leq 0.01$). The value of the other PUFA acids was less than 1 g in 100 g of fat.

The sum of PUFA acids in the calves in pen group was 9.67 g, while in the calves with foster cows group it was 11.32 g (1.65 g higher than the calves in pen group) ($p \leq 0.05$). As for the group of fatty acids included in PUFA n-6, their content in the calves in pen group was 8.55 g, while in the calves with foster cows group it was 10.06 g, higher by 1.51 g ($p \leq 0.05$). The PUFA n-3 group in the calves with foster cows group was 0.88 g, while in the calves in pen group it was 1.07 g, higher by 0.19 g ($p \leq 0.01$). The ratio of n-6 to n-3 was higher in the calves in pen group at 9.52, while in the calves with foster cows group it is 8.95, 0.57 less ($p \leq 0.05$).

### 3.4.2. Oxidative Stability

The collected tissues were subjected to analyses to determine oxidative stability. Figure 8 shows the myoglobin content in the *semimembranosus muscle*. Figure 9 shows the changes in the veal's MDA content. Table 6 shows the changes in meat color.

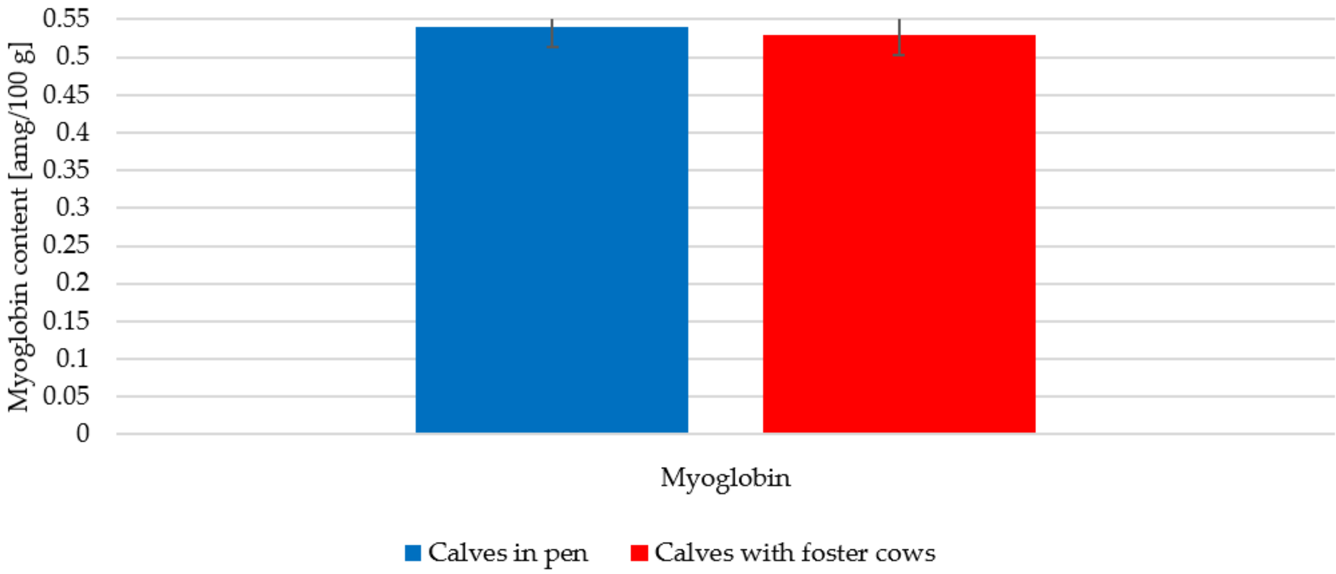


**Figure 8.** Myoglobin content.

The myoglobin content in the collected tissues from both groups was at a similar level: in the calves in pen group, 0.54 mg, while in the calves with foster cows group it was 0.53 mg, a difference of only 0.01 mg ($p \leq 0.725$).

Figure 9 shows the changes in MDA content during storage of the muscle tissue. The first analysis was performed 24 h after slaughter. The MDA value during the first measurement for the calves in pen group was 0.82 mg, while in the calves with foster cows group it was 0.22 mg (0.6 mg lower than in the calves in pen group) ($p \leq 0.01$). The second MDA measurement was made on day seven after slaughter; the MDA level in the calves in pen group increased by 3.73 mg to a value of 4.55 mg, an increase of 454.88%. In the calves with foster cows group it increased by 3.06 mg to a value of 3.28 mg, an increase of 1390.91%. The MDA value was higher in the calves in pen group than in the calves with foster cows group, and this difference at day seven post-slaughter, between the groups was 1.27 mg ($p \leq 0.01$).

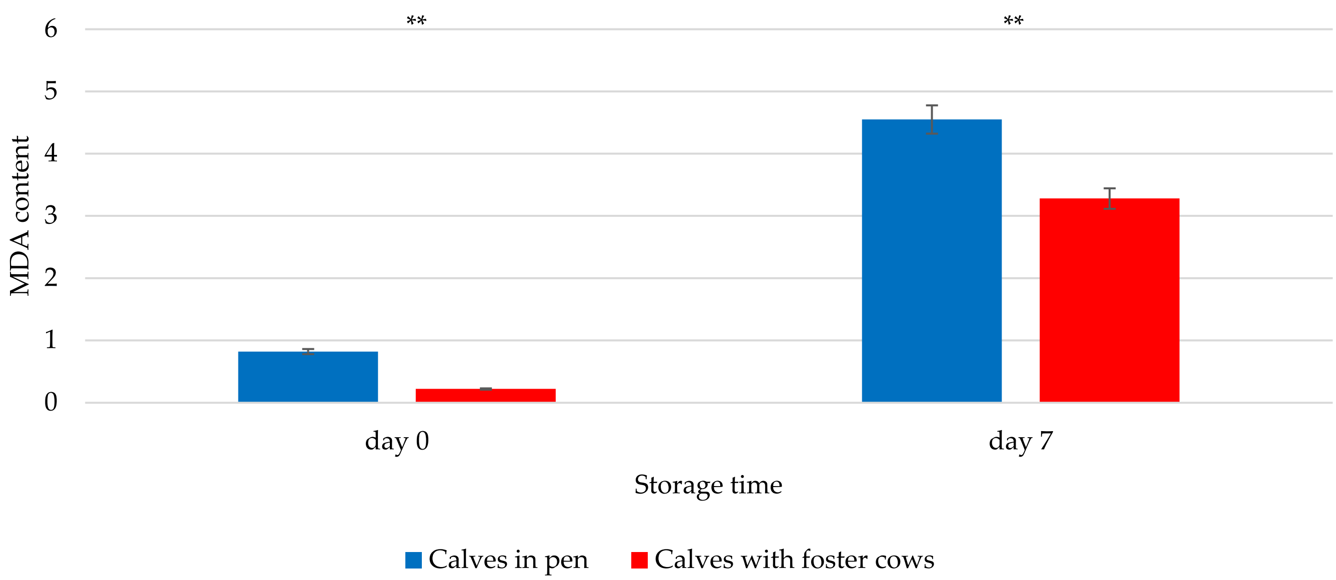


**Figure 9.** Changes in the MDA content of veal in relation on storage time. ** $p \leq 0.01$.

**Table 6.** Changes of color veal.

| | Day | Calves in Pen | | Calves with Foster Cows | | *p*-Value |
|---|---|---|---|---|---|---|
| | | LSM | SEM | LSM | SEM | |
| L* | 1 | 46.25 | 4.551 | 46.13 | 5.487 | 0.830 |
| | 4 | 57.56 | 4.081 | 57.30 | 3.737 | 0.470 |
| | 7 | 45.87 | 4.900 | 44.46 | 2.246 | 0.080 |
| a* | 1 | 18.35 | 3.189 | 18.02 | 2.150 | 0.777 |
| | 4 | 7.41 | 2.969 | 7.82 | 3.750 | 0.293 |
| | 7 | 9.31 | 1.889 | 11.13 | 2.406 | <0.001 |
| b* | 1 | 16.14 | 4.835 | 12.60 | 2.516 | 0.528 |
| | 4 | −4.85 | 2.997 | −4.25 | 5.368 | 0.191 |
| | 7 | 13.10 | 1.856 | 12.72 | 2.249 | 0.545 |
| C* | 1 | 24.53 | 5.401 | 23.86 | 3.104 | 0.571 |
| | 4 | 9.90 | 1.417 | 11.25 | 1.451 | <0.001 |
| | 7 | 16.16 | 2.183 | 16.98 | 2.949 | 0.096 |
| h° | 1 | 40.61 | 4.462 | 40.66 | 2.768 | 0.848 |
| | 4 | 286.96 | 66.749 | 228.29 | 104.858 | <0.001 |
| | 7 | 54.79 | 5.341 | 48.84 | 4.872 | <0.001 |

LSM—least square means. SEM—standard error of LSM.

Another parameter assessed was the color of the calves' meat tissue; this was analyzed three times: the first time at 24 h after slaughter, the second time at four days after slaughter, and the third time at seven days after the slaughter of the calves.

Twenty-four hours after slaughter, the parameters for brightness (L*), redness (a*), yellowness (b*), saturation and pigment content (C*), and degree of hue deviation (h°) were at similar levels in both the calves in pen and calves with the foster cows groups.

On the fourth day after slaughter, the L*, a*, and b* parameters remained at similar levels in both groups. However, the value of saturation and pigment content was distinctly higher for the calves with foster cows group while the degree of hue deviation was lower than that of the calves in pen group. As for the changes between the individual measurements, there was an increase in the values of the L* and h° parameters, but a decrease in the other parameter values.

On the seventh day after slaughter, the values of the L* and b* parameters for both groups remained at a similar level. The C* parameter was also at a similar level, while the value of the a* parameter was higher in the calves with foster cows group. In the case of the h° parameter, as on the fourth day after slaughter, the parameter had lower values in the calves with foster cows group. As for changes between individual measurements, there was an increase in the values of a*, b*, C*, while L* and h° decreased.

## 4. Discussion

### *4.1. Animal Behavior*

Animal behavior is a complex outcome influenced by various factors, holding significance not only for the animals within a group but also for the caregivers. Proper behavior development in animals is closely tied to their natural way of life [58,59], particularly during the critical period from birth and contact with the mother. Before birth, mothers often seek isolation from the herd for calving, followed by a period of licking the newborn calf for over 30 min [60]. During this time, a bond forms between the calf and its mother, and the calf receives vital colostrum. However, calves frequently face challenges in successfully taking in colostrum due to factors like the structure of the cow's udder and the weakness of newborn calves [61–64]. Concerns about the right quantity, quality, and timing of colostrum intake are reasons why some farmers choose to separate calves from their mothers immediately after birth or shortly thereafter. Depending on the farm's size and infrastructure, various methods are used for calf feeding. This can include using buckets equipped with teats, feeding once or twice a day, or employing special vending machines that provide calves with constant access to colostrum, milk, or milk replacer, mimicking a more natural process where calves have some control over the timing of their intake [48,65]. In essence, proper behavior development in animals, particularly in the early stages, is closely linked to maternal bonding and colostrum intake, and farmers employ different strategies to ensure the health and well-being of their calves. The observations regarding calf behavior and their interactions with their mothers or the rearing environment underscore the complexity of calf rearing practices. The initial bonding and colostrum intake facilitated by maternal care are crucial for calf health and immunity. However, challenges in ensuring adequate colostrum consumption and concerns about calf well-being have led to the adoption of various rearing methods. Calves separated from their mothers and provided with controlled access to milk through buckets or vending machines can have distinct behavioral patterns. They may exhibit a higher frequency of sucking and licking behaviors as they adapt to this different feeding system (Figures 1 and 2). On the other hand, calves reared by their mothers tend to have longer suckling sessions but may eventually display more independent behaviors. According to Rosenberger et al., calves can take in as much as 12 L of milk per day [66] during 8 to 12 rest [61,67], indicating fairly small amounts of milk intake per rest period. During this time, calves have the opportunity to calm their suckling reflex. According to Appleby et al. [68], calves that stay with their mothers suckle for an average of 47 min; while, according to Hammell et al., calves drinking from a bucket provided with a pacifier suckle for only 18 min per day [69]. In an experiment in which calves that were given constant access to vending machines, but were given colostrum, milk or milk replacer twice a day, the animals appeared near the machines throughout the day [66,70,71] and showed an eagerness to take goo through sucking and licking reflexes, while animals staying with their mothers showed such behavior much less frequently [65]. A similar trend was evident in our study, where animals that were fed using an automatic feeder showed more frequent desire to lick and suck other animals as well as objects in their environment [72] compared to animals in the experimental group, where calves had permanent access to foster cows.

Calves in the experimental group consistently fulfilled their food requirements and showed little need to lick and suckle other individuals or objects. Similar observations were confirmed in a study by Margerison et al. [65]. However, as indicated by our own research and that of de Passille et al. [71], at a later age, calves that stayed with their mothers can manifest an increased number of such behaviors—this may be related to reduced milk production and not fully covering the maintenance requirement. According to Whalin et al. [73], the actions of licking and suckling other individuals and objects is probably related not only to the desire to retrieve food and satisfy the natural need to suckle, but may also be related to the need for skin and head hair cleaning in calves, which is performed by cows, as well as the formation of social bonds between individuals. As indicated by several authors [32,33,40,41,73] these actions are not only related to the presence of their mothers but are also dependent on the age at which the calves are weaned.

Restricted feed intake only at a designated time, according to a study by Hammon et al. [33], affects not only the behavior but also the physiological state of the animals [74]. Animals fed at a set time were characterized by higher levels of cortisol in the blood, which indicates the occurrence in these animals of stress associated with feed intake restrictions and increases the reduction of immunity [75,76]. Animals that stay with their mothers take in more feed, which may, additionally, stimulate their growth. Also, calves staying longer with their mother were associated with the mimicking of her behavior and taking in solid feed [77]. However, as stressed by farmers, animals that are reared by a human are more docile and easier to handle than those animals that stayed with their mothers [50,51,67].

It is worth noting that the weaning age and feeding schedules play significant roles in shaping calf behavior. Calves weaned at different ages may exhibit variations in their social interactions and feeding-related behaviors. Moreover, the impact of rearing methods on physiological aspects, such as cortisol levels and immunity, highlights the importance of considering both behavioral and physiological indicators of calf well-being. Ultimately, the choice of rearing method should be based on a careful assessment of the welfare, health, and growth of the calves, as well as the management practices and resources available on the farm. Balancing the natural behaviors of calves with the practicalities of farm operations remains a critical consideration in calf rearing decisions.

### 4.2. Animal Health

Disease prevention plays a very important role in animal maintenance. According to Palczynski et al. [78] preventive measures can reduce the occurrence of diseases and thus reduce the frequency of treatment, including the administration of antibiotics, and therefore reduce costs and increase the possibility of achieving better results. There is a huge problem with calf health [78] and calf mortality [77] in dairy herds. As indicated in a study by Palczynski et al. [74], farmers very often report concerns about calves having an adequate enough transfer of passive immunity, which is associated with an inadequate intake and quality of colostrum, and the timing of colostrum intake by calves that stay with foster cows [62,79]. Therefore, more disease entities are possible; but studies have not clearly defined the etiology of the occurrence of various disease entities.

Diarrhea is a common health concern in young calves and can have significant implications for their growth and well-being. The data indicate that diarrhea was more prevalent in the control group of calves reared conventionally in pens. This could be attributed to factors such as stress associated with separation from the mother, suboptimal colostrum intake, and the feeding regimen. In contrast, the group of calves with foster cows experienced a notably lower incidence of diarrhea. The presence of foster cows may have contributed to reduced stress and better feeding practices, resulting in improved calf health (Figure 3). As Meagher et al. and Beaver et al. point out in their review [40,41], it is possible for animals that stay with their mothers to contract various disease entities that are mainly related to the presence of inflammation of the mammary gland, which causes diarrhea. Diarrhea and respiratory disorders are the most frequently mentioned disease entities occurring in calves [58–60,78]. In our study, animals in the experimental group showed significantly better health than those in the control group, and it was noted that only one individual developed diarrhea during the course of the experiment. However, when fed whole milk, diarrhea is very often mistaken for watery feces, which is a normal phenomenon [40,41].

On the other hand, when it comes to the occurrence of respiratory conditions, pneumonia is the most common problem. In our study, the occurrence of this disease was excluded through examinations performed by a veterinarian, although coughs and rhinitis were confirmed. Coughing is often associated with respiratory issues in calves. The data show that coughing occurred in both the control and experimental groups. However, the onset of coughing in the group of calves with foster cows was delayed, with the first occurrence noted in the sixth month of the experiment and affecting only one calf. This delayed onset suggests that the rearing conditions, including the presence of foster cows, may have provided a more favorable respiratory environment for the calves. The control group, reared conventionally in pens, experienced coughing earlier and in multiple individuals. Rhinitis, or inflammation of the nasal passages, is another respiratory condition that can impact calf health. The results indicate that rhinitis occurred primarily in the control group during the early months of the experiment, affecting multiple individuals. In contrast, no cases of rhinitis were reported in the calves with foster cows. This observation suggests that the rearing system involving permanent access to foster cows may have contributed to a lower incidence of respiratory issues in the experimental group.

The elimination of the occurrence of diseases in young calves is a very important factor that affects not only the cost of production, but, above all, its efficiency, because only after eliminating the occurrence of diseases can all physiological processes run properly. In summary, the data suggest that the rearing system involving foster cows may have advantages in terms of reducing the incidence of diarrhea, delaying the onset of coughing, and preventing rhinitis in calves compared to conventional rearing in pens. These findings highlight the potential benefits of incorporating maternal care and natural behaviors into calf rearing practices, ultimately promoting better calf health and welfare. However, further research and monitoring are needed to validate these trends and assess long-term effects on calf development.

### *4.3. Body Weight*

The proper growth and development of calves is influenced by many factors, especially environmental factors, the most important of which are nutrition and the health of the animals. Animal weight and weight gain depend on whether the animals' feed requirements are fully covered. If animals are not provided with adequate nutrition, their growth rates may be lower [63,66,80]. The daily weight gain of calves is a critical factor in determining their overall growth and development. In this study, the calves with foster cows consistently exhibited higher daily weight gains compared to the control group, reared conventionally in pens. This difference was evident from the early stages of the experiment and persisted throughout (Figure 7). The consistently higher daily weight gain in the group of calves with foster cows has important implications for their weight at slaughter. The data suggest that these calves have the potential to reach higher slaughter weights compared to those reared conventionally (Figure 7). This finding is of significance in the context of meat production, as it implies the possibility of obtaining larger and potentially more valuable carcasses.

As Hammon et al. [81] point out, the use of restricted milk intake during the rearing period is associated with the occurrence of higher blood cortisol levels compared to animals with constant access to colostrum, milk or milk replacer, which indicates the occurrence of stress in these animals, associated with the restrictions in feed intake, and may result in reduced immunity [64,75,76]. In addition, in an experiment by Hammon et al. [81], this type of rearing was associated with the presence of high levels of non-esterified fatty acids (NEFA), which may indicate the periodic occurrence of negative energy balances (NEB) in these calves [75].

In our study, the body weight of the animals in the experimental group was higher for each successive measurement compared to that of the animals in the control group. These animals also had higher daily gains. These studies confirm the results of Khan et al. [82] and Chapman et al. [83]. Animals in the experimental group, having constant access to milk, independently chose the time of day when they wanted to feed, due to which they did not feel hungry, and, as indicated by the presence of foster mother, may stimulate calves to intake solid feed earlier. This is related to the imitation of behavior that calves observe in the foster mother.

Several factors may contribute to the enhanced growth observed in the group of calves with foster cows. The presence of foster cows may reduce stress and promote better feeding practices, leading to improved nutrient intake and growth. Additionally, the natural behavior of suckling from a mother cow may result in more efficient feeding and higher weight gain (Figure 7). As Khan et al. [82] indicate, animals permanently housed with foster mother usually begin solid feed intake earlier, but as a result do not take in too much solid feed; while animals fed limited amounts of milk or milk replacer, due to feelings of hunger, at the same time take in more solid feed [84]. However, as Johnsen et al. point out, despite the intake of a larger amount of solid feed, very often, insufficient milk intake will delay the subsequent growth of such calves [45]. In our own research, the growth rate of the calves from the control group may have been further affected by the occurrence of diarrhea, but also rhinitis and coughing, indicating the presence of lowered immunity. This leads to increased nutritional requirements to fight the disease but may, at the same time, cause a lower willingness to take food, which confirms results obtained by Stanton et al., Windeyer et al., and Renaud et al. [43,85,86].

### 4.4. Quality of Veal

Increasing consumer awareness of food is of great importance in shaping the highest possible quality, which, in turn, has a decisive role in the nutritional value of the raw material. Veal is considered by many to be a delicatessen meat, high in protein and fat, and rich in bioactive compounds. The content of individual fractions depends on factors such as genotype and environment, i.e., nutritional health status and stress. According to Domaradzki et al. [28], the average protein content of veal is at a level of 20.7–23.3%. In our study, the protein content was 31.24 g in the control group, and 33.4 g in the experimental group; a 31.24–33.4% protein content in meat, is a very high value, representing very high meat quality. Bittante et al. [87] obtained definitively lower values in their study on calves derived from crossbreeding dairy breeds with meat breeds, obtaining values of 20.70–22.20%. In addition to the amount of protein in the meat, intramuscular fat content and fatty acid profile play a very important role, despite their fairly low values in the meat's composition [88,89].

According to Domaradzki et al. [28], in their study, the intramuscular fat content varied between 0.4% and 2.5%; while in our study the intramuscular fat content was 1.85 g in the control group and 1.47 g in the experimental group, with a total fat content of 2.01 g in the control group and 1.88 g in the experimental group. Calves in the experimental group were characterized by lower total and, thus, lower intramuscular fat content compared to the control group. In contrast, Bittante et al. [87] obtained results of 1.97–4.32%. Intramuscular fat plays a rather important role in shaping the quality of veal. In most cases, SFAs in meat have a dominant role over MUFA and PUFA groups. As indicated by Domaradzki et al. [28], they make up from 33.99% to 52.4% of fatty acids, while MUFAs make up 29.38–51.00%, and PUFAs 5.35–30.80%. In our study, the SFA content was 37.15%, MUFA 36.35%, and PUFA 9.67%, meaning that the values are similar to previously published works.

The predominant role in veal SFAs is played by C16:0 and C18:0, while for MUFAs it is C18:1 cis9, and C6:1 cis9, and for PUFAs C18:2 n-6, C20:4 n-6, as confirmed by our own studies [81,85,90,91].

### 4.5. Oxidative Stability

A number of biochemical processes take place in meat after slaughter, leading to meat maturation. According to Ripoll et al. [92], producing high-quality products should be the goal of producers, so it is important that the raw materials obtained have adequate oxidative stability [93]. Among the parameters affecting oxidative stability, we can mention meat color, which directly affects its appearance, and is one of the first factors in determining the consumer's choice of meat.

Meat color depends on a number of conditions, starting with pre-slaughter factors that affect the post-slaughter factors including oxidative stress and myoglobin content. In our study, the myoglobin content in the control group was at a higher level than in the experimental group, but the differences between the groups were small—which is a desirable phenomenon. During the maturation process, the color of meat may change due to progressive oxidation processes, which can lead to meat spoilage [93]. Oxidation products are formed during the oxidation of lipids and proteins, indicating a loss of meat quality. Results on oxidative stability are very important from the point of view of the consumer, so there are many results for the most popular types of meat, such as pork, beef, and poultry meat, while for veal there are a very few reports in which this topic has been addressed.

In a study by Lušnic Polak et al. [93], the value of the L* parameter 24 h after slaughtering was at a similar level (48.36) to that in our own study (46.25–46.13), and similar to values obtained by Bittante et al. [87]. While in the case of the a* and b* parameters, the values were significantly lower (a* 11.79 and b* 2.80 [93] and a* 7.40b*–8.2 and a* 13.60b*–14.20 [87]) than in our own study (a* 18.35–18.02 and b* 16.14–12.60, respectively). On the seventh day of meat maturation, the parameters in the study by Lušnic Polak et al. [93] increased while in our own study the values decreased slightly. As Henriott et al. [94] points out, a decrease in values may favorably indicate the meat's adequate oxidative stability and a low oxidation value for myoglobin. The obtained eigenvalues differ from the results published by Florek et al. [90] and Vitale et al. [95].

Another parameter indicating the oxidative stability of meat in our study was the change in TBARS values for malondialdehyde (MDA). In the case of MDA, the values on the day of slaughter were lower in the experimental group (0.22 mg) than in the control group (0.82 mg). During the 7-day meat storage, MDA values in both groups increased—to a level of 3.73 mg in the experimental group, while in the control group to 4.55 mg. Higher TBARS values indicate higher levels of oxidation, but as Penko et al. [96] points out, this does not always change sensory characteristics. Meat with high TBARS values is not desirable, therefore, as indicated by Clausen et al. [97], the best solution is to vacuum package the meat, which protects the meat from the oxygen present in the atmosphere.

## 5. Conclusions

In summary, this study sheds light on the implications of rearing methods on various aspects of calf health and behavior. The presence of foster cows in the rearing environment emerged as a favorable factor, leading to improved calf health outcomes. Specifically, calves reared alongside foster cows exhibited reduced rates of diarrhea, delayed instances of coughing, and a diminished occurrence of rhinitis when compared to conventionally reared counterparts confined to pens. Behavioral observations unveiled distinctions in sucking and licking behaviors between the two groups. Calves with foster cows displayed a more consistent pattern of these behaviors, while conventionally reared calves exhibited greater variability. Moreover, this research underscores that calves reared alongside foster cows consistently attained higher daily weight gains. This finding implies the potential for larger and more valuable carcasses upon slaughter. Consequently, the rearing system involving foster cows presents notable advantages in terms of both calf health and growth. Notably, the study did not reveal significant disparities in the fatty acid composition, color attributes, or myoglobin levels of veal between the two rearing groups, implying that meat quality remained consistent. In light of these findings, this research encourages the exploration and adoption of rearing systems that prioritize calf health, behavior, and growth, underpinned by maternal care and natural behaviors. Such endeavors hold promise for enhancing the well-being of calves and the sustainability of the meat production industry. Additionally, the incorporation of foster cows into dairy farming practices may represent a pragmatic and effective approach to advancing calf rearing protocols.

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