A Preliminary Study on the Effect of Different Feeding Regimes on the Physiochemical Characteristics of Local Sheep’s Milk

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Abstract: The herding of sheep has been part of the Maltese food supply chain for a long time. Sheep were mainly kept for milk, meat, and wool. Local sheep milk was and is still in use for cheese production, especially cheeselets. The participants in this study were local sheep that were fed different feeding regimes. In total, 6 farms were identified; these were scattered throughout the main island and comprised four different feeding regimes. Milk samples were collected during early, mid, and late lactation. Samples were taken directly from the pail or milk tank before starting the process to transform this milk into cheeselets, i.e., exactly after milking. Samples were analyzed the day after in the laboratory using the Lactoscan SP milk analyser. Data gathered included fat percentage, protein, lactose, freezing point, and salts. The best milk fat results in this research were obtained by the group fed concentrates, dried hay, and which had an hour’s grazing per day. The group fed concentrates which had three hours of grazing per day got the best results with regard to protein, lactose, and salt content in the milk. This means that a good energy: protein ratio in the feed is important as all ingredients found in the raw milk have an important function. Therefore, reaching the best level of each is the main priority for the farmer to obtain a final product of good quality.

Keywords: milk chemical composition; sheep milk quality; feeding regimes; milk analysis; raw milk

Introduction

Malta has a long tradition of herding, with the earliest known references dating back to Punic times. Synonymous with such a tradition is cheesemaking and Malta is no exception to this practice. Throughout the ages, several references can be found to a handful of different cheeses, typically produced in various localities of Malta in different epochs and historical contexts. Probably the most well-known of these is the cheeselet, which in Maltese is called ‘ġbejna’. Cheeselets come in three forms: a fresh watery version stored in its own whey, ‘friski/tal-ilma’; a sun-dried version, ‘moxxa’; and a cured version, usually with salt, called ‘maħsula’ and/or the crushed black pepper version thereof, or ‘tal-bżar’, which in turn may also be pickled in vinegar, stored in oil, or aged in airtight containers. It is known that this cheese was a staple in Malta for at least the past five hundred years. According to the NSO Agriculture and Fisheries Census (2014), in Malta, there is a sheep population of around 10,526 heads and, between them, they produce around 1,546 tonnes of milk per year. 95.4% of this milk is transformed into cheeselets while the rest is used for own consumption. From this milk, the sheep farmers supply the market with around 6,000 tonnes of cheeselets per year. Most of the sheep farms are found on the island of Gozo while in Malta most of the farms are found in the southern part of the island, as shown in Figure 1. According to Spiteri and Attard (2019), the ovine breeds found in Malta are the Comisana, the East Friesian, the Maltese, and the Crossbreed.
Literature Review

Sheep produce milk rich in total solids which make it important in the cheese industry. The total milk solids play an important role in cheesemaking because they are the main ingredients to make cheese. According to Fox et al. (2004), milk total solids mainly consist of lactose, casein, and fats. Lactose is used in the first part of cheese-making in the process called souring. During this process, bacteria present in the milk transforms the milk lactose into lactic acid, which drops the pH of the milk and changes the taste of the milk. The casein (milk protein) and fats constitute the solid part of the cheese. What is not transformed into cheese will ooze out as whey.

Fats also contribute to the taste of the milk, and in turn, the taste of the cheese made from this milk can also be attributed to what is ingested by the animal during feeding (Fox and Cogan 2004). According to the same authors, the breed can affect both the milk production and even its quality. The stage of production and the procedure used to produce the cheese can all affect the cheese quality and quantity (Nudda et al. 2019). In another study, Marques et al. (2011) found that the lactation period can affect the milk yield and the nutritional content in the sheep milk which can later affect the final product quality.

Nutrition provided to the sheep during lactation directly affects their milk production with regard to yield and quality (Bencini and Pulina 1997; Bocquier and Caja 2001; Monrand-Fehr et al. 2007; Nudda et al. 2004). Therefore, the feeding regime chosen by the farmer will affect his end products. According to a study carried out by Voutzourakis et al. (2020), the amount and type of concentrate and forage seeds or grazing time can influence the milk composition of dairy sheep. In this study, it was reported that extensive flocks raised on grazing produced 37% less milk but with 11.5% higher fat content when compared with semi-intensive flocks with less access to grazing. In another study carried out by Maamouri et al. (2011), it was reported that sheep on pastures produce milk high in fat when compared to others which were fed hay or silage. All groups were given concentrates as well. Sanz Sampelayo (2007) states that pasture feeding with a high fibre/energy relation increases fat in milk, while fat is reduced with the inclusion of concentrate in the diet. Jenkins and
McGuire (2006) report that the diet of lactating ruminants can modify the fatty acids (FA) composition of milk (and cheese) to a certain extent. This can result in a positive health effect on the final consumer. Fat can vary as well throughout the lactation period. In a recent study carried out by Spiteri and Attard (2019) on Maltese sheep, they found that milk fat in sheep can be low at the beginning of lactation (5.64%), can increase at mid-lactation (6.33%), and decreases again at the end of the lactation period (5.99%). With regard to the solids non-fat (SNF) content in milk, this is made up of protein (mainly casein and lactalbumin), carbohydrates (mainly lactose), and other minerals (Spiteri and Attard 2019). In their study, the average SNF content in sheep milk was about 10.5%. Generally, the fat content in the milk has a positive correlation with the SNF content. Kondyli et al. (2012) report that studies show that breed differences may not reflect significant differences in SNF content.

Protein is made up of amino acids which have an amino group in their structure. When broken down, this will release nitrogen (N). Nudda et al 2019 state that, in general, an increase in dietary protein does not affect milk protein content but can influence the N milk fraction. They argue that milk’s true protein concentration is largely genetically controlled, and the effect of nutritional means is very limited. Another study carried out by Pulina et al. (2006) argues that the largest part of N in milk is coming from true protein (approximately 95%), but there is a poor association between the N intake and the crude protein (CP) dietary content. In their research paper, they state that milk true protein depends on the metabolizable protein found in the diet, the production of microbial protein at rumen level, and the protein:energy ratio in the diet. Milk true protein is mainly made up of approximately 80% casein and the rest is whey or serum proteins, immunoglobulins, enzymes and enzymes inhibitors, metal (lactoferrin) and vitamin binding proteins, several growth factors, low molecular weight peptides (protease-peptone), and bioactive peptides (Claeys et al. 2013; Claeys et al. 2014; Pereira 2014). Increases in N intake and N dietary cause an increase in blood urea levels that are proportionally linked to both the urinary N and nonprotein N (NPN) fraction of milk, especially milk urea (Cannas et al. 1998; Giovanetti 2006). Taking into consideration that sheep prefer legumes, according to Nudda et al. (2020), these plants are rich in protein—something which can lead to higher N intake—but they are also rich in polyunsaturated fatty acids (PUFA). This is most apparent in animals that have access to grazing and in those that are fed silages made from legumes. Spiteri and Attard (2019) report that the sheep milk protein in Malta is approximately 3.77%.

The major carbohydrate in milk is lactose. According to Spiteri and Attard (2019), its content in milk depends on the lactation period and they found that the mean lactose level in local sheep is around 5.56%. Other various studies by Antunac et al. (2008), Kondyli et al. (2012), Marques et al. (2012), and Martini et al. (2010) reported a lactose level that varies between 4.44 and 5.06%. This high difference in the lactose level in sheep milk can also be explained by the hygiene level on the farm. According to Leitner et al. (2004), lactose concentrations are reduced during clinical and subclinical mastitis in sheep. The farm’s sanitary conditions can affect the pH level of the milk as well. According to Spiteri and Attard (2019), bacteria play an important role in milk pH, because bacteria like lactobacilli convert sugars in milk into acids, hence reducing its pH level. They also report that there are other bacteria that convert milk components into ammonia products, hence increasing milk pH levels. Therefore, milk pH can also serve as an indicator of farm hygiene and livestock health conditions.

The salt content in milk mainly consists of calcium (Ca), phosphorus (P), potassium (K), and magnesium (Mg). The amounts found in Malta in a previous study on sheep milk were those of 0.8% (Spiteri and Attard 2019). Although in small amounts, they play an important role in the milk’s technological properties as some salts influence the stability and physical state of the protein, particularly caseinate (Bijl et al. 2013; Bornaz et al. 2009). The feeding
regime can also influence mineral concentrations in milk, such as iodine (Nudda et al. 2009), iron, zinc, and cobalt (Khan et al. 2006). The main factor which can affect the iodine concentration in milk is pasture-based diets. According to Nudda et al. (2019), iodine is an important mineral for infants and children. Therefore, sheep milk can also be an important source. This study found that iodine concentrations were higher when the sheep were fed more concentrates and had less access to pastures. On the other hand, selenium higher in milk when the sheep grazed on pastures rather than being fed indoors on concentrates.

According to De Renobales et al. (2012), studies performed on sheep’s and goat’s milk mainly investigate three large groups of feeding regimes, namely: those that graze on natural or cultivated pastures, with or without additional concentrates and/or supplements; those that are fed different forage, mainly concentrate ratios with or without oil supplements; and those that are fed concentrate feed with various supplements such as vegetable oils, oilseeds, fish oil and cereals—alone or combined. In their report, De Renobales et al. (2012) conclude that part-time grazing has better results when compared with sheep reared indoors, especially during the spring period. The difference shows itself in the milk’s nutritional content, increased milk yields (by 30%), and a reduction in the production costs.

Although the cheeslets’ recipe is well known today, variations in recipes, modern additives, such as herbs and spices, feed variances, grazing habits, and local flora variances all contribute to an array of different tastes and different consistencies. Such variances in taste and consistency merit further investigation, primarily to establish any correlations, but more importantly to give more intrinsic value to this typical food product in the hope of preserving this age-old tradition while also enhancing marketability. For this reason, this research has focused on the physio-chemical characteristic of the milk and how it varies during the lactation period and with different feeding regimes.

**Methods**

This is a 6-months-long (December 2020 till May 2021) longitudinal study which gathered data from farms with different feeding regimes in Malta. This period was chosen as it is the most common lactation period for local sheep. In total, 6 farms were researched and these were scattered throughout the main island and comprised four different feeding regimes, as shown in Table 1. All farms were feeding concentrates with similar nutritive values (crude protein 18%; fats 3%; crude fibre 6%; ash 7%; Na 0.4%) as part of their diet. However, two farms were taking out their herd for grazing (3 hours on a garrigue landscape) every day (Group 1); one farm was supplying its herd with cut grass (vegetables leftovers) when available as well as dried hay (Group 2); two farms were supplying dried hay (Group 3); and another farm was taking out its herd grazing (1 hour in a valley landscape) every day and supplying its sheep with dried hay as well (Group 4). The level of concentrates given daily varied between the groups. Group 1 was feeding around 1400g/head concentrates, Group 2 around 1300g/head, Group 3 around 1200g/head, while Group 4 was around 1250g/head. The third group has the most common system used in Malta as it is convenient given that land costs a lot of money to purchase and most sheep farmers are part-timers. Part-time farmers have less time available to dedicate to grazing. To use such a practice, they need to purchase land which is expensive.
<table>
<thead>
<tr>
<th>Group Number</th>
<th>Feeding Regime</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Taking the herd for grazing (3 hours on a garrigue landscape) every day and feeding them 1400g/head/day concentrates</td>
</tr>
<tr>
<td>2</td>
<td>Supplying the herd with cut grass (vegetables leftovers) when available, 1800g/head/day dried hay, and 1300g/head/day concentrates</td>
</tr>
<tr>
<td>3</td>
<td>Supplying 1300g/head/day dried hay, and 1200g/head/day concentrates</td>
</tr>
<tr>
<td>4</td>
<td>Taking the herd grazing (1 hour in a valley landscape) every day, 1250g/head/day dried hay, and 1250g/head/day concentrates.</td>
</tr>
</tbody>
</table>

Table 1: Feeding regimes under research

**Sampling**

The pool sampling technique was chosen to get an overview of the milk composition of the herds under investigation using the different feeding regimes. Samples were taken directly from the pail or the milk tank before starting the process of transforming this milk into cheeslets, i.e., exactly after milking. Each farm was visited 3 times—at the beginning of the lactation period, at mid-lactation, and at the end. Therefore, a total of 18 milk samples were collected from the farms. This was done as, according to Marques et al. (2011), the lactation day can affect both the milk yield and even the composition of milk. By taking these 3 samples, the researcher attained a clear picture of the mean composition of sheep milk in each feeding regime. Samples were kept in a refrigerator and analysed the day after in the laboratory using the Lactoscan SP milk analyser, as shown in Figure 2. This equipment is commonly used in the industry to measure the chemical composition of milk coming from bovines and ovines. The results are obtained in a short period of time. Data gathered included fat percentage, protein, lactose, freezing point, and salts.

*Figure 2: Lactoscan SP milk analyser*
Sample Preparation

Sample preparation followed the procedure used by Spiteri and Attard (2019) in their research. This research was carried out on the main Maltese island so as to compare milk coming from bovines, caprines, and ovines. This procedure was followed so as to be able to compare the results with theirs (Spiteri and Attard) and it has already proved reliable and valid. Therefore, milk samples were left to acclimatize in warm water at 30ºC for 30 minutes. Following this, 15ml aliquots of milk were transferred from the 100ml sample bottle to the recipient which was used for testing. Therefore, each sample was divided into 4 aliquots of 15ml each. The equipment was then switched on, left to calibrate, and the milk type was selected on the display screen. The result was issued after one minute.

Data Analysis

This research consists of 4 independent variables, which are the 4 types of feeding regimes, and 5 dependent variables, which are fat, protein, lactose, SNF, and the salts concentrations in the sheep milk. The researcher used the One-Way ANOVA test to analyse if there is any statistically significant difference between the independent variables with regard to the dependent variables. A post hoc test named Hochberg was used to identify if there were any feeding regimes with similar results. This test was chosen as the amount of data (n) in each group is not identical. The data was analysed as well to check if there is any statistically significant correlation between the type of feed and the nutrient content in the milk. For this purpose, the researcher used the Pearson correlation test. All tests were run using the SPSS software package.

Results

The chemical composition of milk, especially ovine milk, is very important because it has a prime role in cheese making (Marques et al. 2011). Table 2 presents the One-Way ANOVA conducted to compare the four different feeding regimes in relation to protein, lactose, fat, and salt content in the milk. The researcher conducted a post hoc test to identify if they fall in different subsets as well.

<table>
<thead>
<tr>
<th>ANOVA</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
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<tr>
<td>Between Groups</td>
<td>Within Groups</td>
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<td>63</td>
<td>.007</td>
<td></td>
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<tr>
<td>Total</td>
<td>.902</td>
<td>66</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fat%</td>
<td>Between Groups</td>
<td>12.350</td>
<td>3</td>
<td>4.117</td>
<td>11.165</td>
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<tr>
<td>Between Groups</td>
<td>Within Groups</td>
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<td></td>
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<tr>
<td>Total</td>
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<td></td>
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<tr>
<td>Salts</td>
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<td>3</td>
<td>.007</td>
<td>32.461</td>
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<td>Within Groups</td>
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<td>.000</td>
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<tr>
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<tr>
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<td>.143</td>
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<td>Between Groups</td>
<td>Within Groups</td>
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<td>63</td>
<td>.006</td>
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<tr>
<td>Total</td>
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</table>

Table 2: Results of the One-Way ANOVA test (feeding regimes)
Comparison of feeding regimes’ in relation to protein content in the milk

With regard to protein levels found in the sheep milk under research, there was a difference between the 4 different feeding regimes. In the grazing group (Group 1), the mean protein level was 4.7% (±0.08); the cut grass group (Group 2) and the group fed dried hay (Group 3) both registered a mean protein level of 4.6% (±0.08, ±0.1); while the grazing and dried hay group (Group 4) registered a mean level of 4.48% (±0.05). This equates to a difference of 0.22% between the highest and the lowest level registered. The One-Way ANOVA test showed a statistically significant result with a p-value less than 0.05, which means that the difference between the 4 groups is proven significant and therefore the result is repeatable. The group feeding the most concentrates showed the highest protein level. In previous studies, it was stated that protein is mostly controlled through genetics, however, the feeding regime can have an impact on the protein content found in milk as well (Nudda et al. 2019). Milk protein in ewes can affect the milk coagulation properties as well (Cellesi et al. 2019). They have an important role to entrap the fat found in the milk and form a gel. The main protein in this action is casein, which forms 80% of the true protein found in sheep milk. Previous research reported a broad spectrum with respect to protein. The lowest level, 3.77%, was reported in a local study by Spiteri and Attard (2019), while the highest level, 5.95%, was recorded by Carloni et al. (2015). Other studies carried out by Evtodienco et al. (2015), Cellesi et al. (2019), Ivandre et al. (2015), Carpono et al., (2013), Renobales et al. (2012), and Voutzourakis et al. (2020), all reported levels which fall between 3.77% and 5.95%. The latter 2 reports got a similar results to this one, with both studies reporting a level higher than that found in this research, 4.99% and 5.2% respectively. This conforms with the theory that the protein level in milk is controlled by the phenotype of the sheep and a less so by nutrition. The sheep reared in Malta are different from those found in other countries. This research found a higher level of protein in the milk than that reported by Spiteri and Attard (2019), who carried out their research on the same island. The difference here may be due to the feeding regime because different farmers have their own feeding recipes. The study findings of this research do not match with the findings reported by Voutzourakis et al. (2020), which found that sheep reared in an extensive system have a higher value of protein in their milk. This research found an opposite pattern, where sheep only fed concentrates and dried hay recorded the highest level of protein (4.7%), while sheep given concentrates with access to grazing recorded the lowest value of 4.48%—a difference of 0.22% from the other group. Overall, the findings of this research fit well with the levels reported in other studies even if they are on the lower side.

Comparison of Feeding Regimes in Relation to Lactose Content in the Milk

The lactose level evinced similar results as the dependent variable protein, with Group 4 having the lowest, with 4.2% (±0.08); with Group 2 and 3 showing similar results, with 4.36% (±0.08) and 4.37% (±0.09) respectively; and Group 1 having the highest value, with 4.47% (±0.08). This means a difference of 0.27% between the highest and the lowest level registered. As shown in Table 1, the One-Way ANOVA showed a statistically significant difference between the groups with a p-value of less than 0.05. The group feeding the most concentrates showed the highest lactose level. Lactose is the sugar component of the milk. Multiple literature give a broad range of lactose levels in sheep milk. This varies between 3.41%, as reported by Ivandre et al. (2015) and the highest level of 5.56%, as reported by Spiteri and Attard (2019). The latter is the value from the research carried out locally, which is higher when compared with the values obtained in this study, which vary between 4.2% and 4.47%. Such a difference can also be attributed to the difference in the feeding regimes each farmer adopts. Other studies carried out by Evtodienco et al. (2015), Cellesi et al. (2019), Carloni et al. (2015), Renobales et al. (2012), and Voutzourakis et al. (2020), all reported levels which range between 3.41% and 5.56%. With respect to an extensive feeding regime as compared with an semi-intensive regime, the study by Voutzourakis et
al. (2020) reported that the highest level was reported by the semi-intensive system. The findings of this research match with those obtained in this research as the highest level was recorded by the sheep kept on concentrates and with access to grazing, therefore ones in a semi-intensive system.

**Comparison of Feeding Regimes in Relation to Salts Content in the Milk**

Salts are mostly related to what sheep eat. The highest result came from Group 1, with 0.73% (±0.1); Groups 2 and 3 obtained similar results, of 0.71 (±0.2); while Group 4 registered the lowest result, with 0.68 (±0.01). This means a minimal difference of 0.05% between the highest and the lowest level registered. This result obtained a p-value of less than 0.05 in the One-Way ANOVA test (Table 1) and therefore it is statistically significant. Salts are another important component that constitute sheep milk's chemical composition. They are important in the coagulation process (Bijl et al. 2013; Bornaz et al. 2009) and even to provide the minerals needed in the consumers' diet (Nudda et al. 2019). As stated by Evtodienco et al. (2015), the most important minerals found in milk are calcium and phosphorus, but they form less than 1% of the milk's total composition. This research found that the higher salt content was found in Group 1, that is, those which were fed concentrates and had access to grazing, while the lowest level was recorded by Group 4, which were fed concentrates, dried hay, and got access to grazing as well. Other studies reported higher levels: 0.8% by Spiteri and Attard (2019) and 0.93% by Ivandre et al. (2015).

**Comparison of Feeding Regimes in Relation to Fat Content in the Milk**

Fats are an important ingredient in cheesemaking. This research found that the highest result was in Group 4, with a mean of 6.6% (±0.96); Group 2 was the second-highest, with 5.9% (±0.21); Group 3 registered the next highest reading, with 5.8% (±0.25); and the lowest fat content was registered by Group 1, with 5.4% (±0.65). This equates to a difference of 1.2% between the highest and the lowest level registered. Like the other variables, fat content showed a statistically significant result with a p-value less than 0.05 (Table 1). The Hochberg post hoc test groups together Groups 1, 2, and 3 in one subset, with Group 4 being placed in another subset. Between the 2 subsets, there is a difference of 1%. The group in which the sheep were fed concentrates and dried hay and were taken out grazing every day got the highest result. Fats are an important ingredient in cheesemaking and therefore their content affect cheese yield and even milk coagulation properties, as reported by Cellesi et al. (2019). Various literature is found on this subject and the levels reported vary between 5.74%, the lowest (Voutzourakis et al. 2020), and 7.28% (Ivandre et al. 2015), the highest. The findings of this research vary between 5.4% and 6.6%, which fit well within the literature and even with the other two studies carried out in the Maltese islands, which reported values of 6.08% (Carpino et al. 2013) and 6.56% (Spiteri and Attard 2019). When compared with the similar studies carried out by Voutzourakis et al. (2020) and Maamouri et al. (2011), the findings match, as both studies reported that the highest value was registered by sheep kept in extensive systems with access to grazing and a high fibre content in their diet. The value recorded in this research is a bit higher; this can mean that more fibre in the diet can result in higher fat content in the milk. This theory is sustained as well by this research, as can be seen in the correlation testing Table 2.

**Relationship Between the Concentrates and Hay Content in the Four Different Feeding Regimes**

The second part of the analysis consisted of several correlation tests to study if there is a statistically significant relationship between the concentrates and hay content in the 4 different feeding regimes in relation to protein, lactose, fats, SNF, salts, and the freezing point of the sheep milk. The results are shown in Table 3 below.
The results in Table 3 show that there is a medium positive correlation between the concentrate level in the feeding regime and the protein (0.470), lactose (0.438), SNF (0.367), and salts (0.479) level in the milk of the sheep. This means that a higher percentage of concentrates in the feed formulation will increase these nutrients. Fats in the milk showed a medium negative correlation of -0.438, and the freezing point showed a low negative correlation of -0.297 with the concentrates level in the feed formulation. This means that when more concentrates are fed to the sheep, the fat content and the freezing point decrease. All these results obtained a statistically significant result with a p-value of less than 0.05.

<table>
<thead>
<tr>
<th>Concentrates</th>
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<th>Hay</th>
<th>Protein %</th>
<th>Lactose %</th>
<th>Fat%</th>
<th>SNF%</th>
<th>Salts</th>
<th>Freezing Point ºC</th>
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<td>.438**</td>
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<td>.000</td>
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<td>.000</td>
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<th>Hay</th>
<th>Pearson Correlation</th>
<th>Concentrates</th>
<th>Hay</th>
<th>Protein %</th>
<th>Lactose %</th>
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</table>

Table 3: Results of the Pearson correlation test

With regard to the relationship between the hay (fibre) content in the feed formulation and the nutrients found in the milk, the results were not all statistically significant. Fats obtained a statistically strong significant positive relationship of 0.609 with the hay content in the feeding regime. This means that the higher fibre content in the feeding regime will, to a certain extent, result in a higher fat content in the milk. With regard to salts, the relationship was a statistically medium significant negative relationship of -0.315. This means that when the farmer increases the fibre content, there is the risk of decreasing the salts content in the milk. The other nutrients obtained a low and non-statistically significant negative relationship with the hay content in the feeding regime.

Relationship Between the Physiochemical Characteristics Found in Local Sheep Milk

This research, as shown in Figure 3, also shows that there is a statistically strong significant positive relationship between protein and lactose (0.964), SNF (0.787), and salts (0.935). Protein also has a statistically medium significant negative relationship with fats (-0.365) and a statistically strong significant negative relationship with the freezing point (-0.908). Lactose has a statistically strong significant positive relationship with SNF (0.812) and salts (0.966). Like protein, lactose has a statistically medium significant negative relationship with fats (-0.367) and a statistically strong significant negative relationship with the freezing point (-0.941). Fats have a statistically medium significant negative relationship with SNF (-0.303) and a statistically strong significant negative relationship with salts (-0.569). The SNF has a statistically strong significant positive relationship with salts (0.778) while it has a statistically strong significant negative relationship with the freezing point (-0.734). Through this research, it was also noted that salts have a statistically strong significant negative relationship with the freezing point (-0.846).
Figure 3: Correlation between the nutrients found in the sheep milk

There is great interaction between the nutrients found in milk and, therefore, an increase in one will lead to an increase in another nutrient. This is beneficial, especially in cheesemaking because the solids in the milk play an important role and affect the cheese yield in a positive way. Therefore, when the farmer improves his feeding regime, he will get a better milk quality which will result in a higher cheese yield.

Conclusion

Cheeselets are an important product for local sheep farmers. Some farmers are even venturing into new products and have started producing hard cheeses with traditional recipes, most of which are at risk of getting lost. For this reason, knowing the composition of the raw milk and the effects of the feeding regime on milk composition will help local farmers improve their management and be more efficient. Being more efficient with regard to feeding, especially on an island like Malta where feed(ing) is a scarce resource—necessitating that most of it be imported—will result in a more environmentally friendly product.

The best results in this research were obtained by Group 4 with regard to the fat content and by Group 1 with regard to protein, lactose, and salts content in the milk. All ingredients found in the raw milk have an important function, therefore reaching the best level of each is the main priority for the farmer. The difference between the four groups in terms
of salt levels is minimal. Protein and lactose both got a difference of 0.22% and 0.27% respectively between the minimum and maximum levels recorded in this research. The greatest difference was recorded in the fats level, with a difference of 1.2% between the minimum and maximum levels recorded in this research. When analysing the feeding regimes used, Group 1 had the highest level of concentrates (1400g per head), which is 150g more concentrates than the amount fed in Group 4. With regard to dried hay, Group 1 was being fed no hay but had access to grazing, while Group 4 was feeding on 1250g dried hay per head and the sheep had access to grazing. This is also evinced by the correlation tests, with the results showing that the concentrates level has a positive effect on the amount of protein, lactose, and salts level in the milk, while the fibre level coming from dried hay and/or grazing has a positive effect on the fat content in the milk.

From the outcome of this research, the author came up with the hypothesis that if the feeding regime in Group 4 can slightly increase the concentrates level and keep the hay and grazing regime as it is, it can obtain a better energy: protein ratio, as suggested by Pulina et al. (2006). Such a change will result in a higher level of protein, lactose, and salts in the sheep milk. This will improve the quality of the milk as well and can result in a higher cheese yield. Such improvements can lead to an increase in the farms’ profit. Another possible suggestion is that farmers provide pastures with legumes in addition to other plants/grasses instead of increasing the level of concentrates in the sheep’s diet, as such an increase in concentrates level can decrease the fat content in the milk (Sanz Sampelayo 2007). This suggestion is also backed by the study carried out by Nudda et al. (2020) in which they state that sheep like legumes and that such plants are rich in protein. Therefore, such practices can improve the energy: protein ratio in the sheep’s diet as well. These factors can be further investigated in future research.

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