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The Effect of Feeding Regime on The Milk Yield in Dairy Cows

A Takarmányozási Rendszer Hatása a Tejtermelésre Tejhasznú Teheneknél.

by

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Abstract

This research analyses the difference in milk quantity when Holstein Friesian cows are provided with maize silage in the feeding ration. Both Farms used in this study are situated in Malta thus both experiencing similar climatic conditions.

The literature review explores how particular roughages such as maize silage and ryegrass affect milk compound values. Literature published by various researchers is conflicting as some promote ryegrass as superior to maize whilst others tend to disagree. Studies have also shown that a mixed blend of ryegrass and maize silage leads to optimum milk production results but no significant change in milk compound values.

Two dairy farms in Malta were used to gather milk production results across a thirteen-month period, from August 2023 until July 2024. Findings have shown that Farm B feeding ryegrass as forage and feeding them twice daily had a higher annual milk production than Farm A feeding maize silage as forage and supplying the Total Mixed Ration (TMR) three times daily. Initially, it seems that feeding cows with ryegrass yields more milk than feeding cows with maize silage. However, it should be noted that the productivity of milk in Farm A increased when comparing July 2023 with July 2024 following a year of feeding maize silage.

Absztrakt

Ez a tanulmány a kukoricaszilázs takarmányadagba történő beillesztésének hatását vizsgálja a Holstein-fríz tehenek tejtermelésére hasonló éghajlati körülmények között, Máltán. Két tehenészetet elemeztek egy tizenhárom hónapos időszakban (2023 augusztusától 2024 júliusáig), hogy összehasonlítsák a tejtermelést, amikor a fő takarmány kukoricaszilázs vagy rozs fű. A szakirodalom ellentmondásos véleményeket tartalmaz arról, hogy a kukoricaszilázs vagy a rozs fű előnyösebb-e, míg néhány tanulmány a kevert takarmány használatát javasolja az optimális tejhozam érdekében, anélkül, hogy jelentős változást tapasztalnának a tej összetételében.

Az A farm, amely a teheneket kukoricaszilázzsal etette napi háromszori teljes keveréktakarmány (TMR) alkalmazásával, a vizsgálati időszak alatt termelékenységnövekedést mutatott. Ugyanakkor a B farm, amely rozsfüvet használt és napi kétszer etetett, magasabb éves tejtermelést ért el. Az eredmények arra utalnak, hogy míg a rozs fű kezdetben nagyobb tejhozamot eredményezhet, a kukoricaszilázs hosszú távú alkalmazása jelentős termelékenységnövekedést hozhat. Ez a kutatás hozzájárul a takarmánytípus szerepéről folytatott vitákhoz a tejtermelés optimalizálása érdekében.

Table of Contents

	Page
1 Introduction……	5
2 Literature Review……....	6
2.1 Effect of increased frequency in meals per day on the milk yield……	6
2.2 Effect of increased frequency in meals per day on milk fat concentration…….....	7
2.3 Variation in milk production results by other conducted studies…….....	9
2.4 Impact of feeding frequency on milk productivity of cows in heat stress……..	10
2.5 Effect of feeding dairy cows at delayed stage compared to feeding straight post milking…….	11
2.6 Corn silage characteristics…….....	13
2.7 Positive impact of maize silage on lactating and dry cows……	14
2.8 NDF and starch proportions in silage and its effect on milk production…….	15
2.9 Replacing grass silage with maize silage as main dietary forage for dairy cows…….	17
3.0 Replacing rye grass with other forages…….	18
3.1 Effect of DM content of corn silage on milk yield, and composition……	18
3.2 Changes in maize silage components at different stages of maize crop maturity……	19
3.3 Maize silage effect on DMI, milk yield and fat in dairy cattle and buffaloes…….	19
3.4 Replacing maize silage with an alternative forage in water limited regions……	20
3.5 Increasing the NDF of maize silage……..	21
3.6 Automatic Feeding System and Robotic Milking……	22
3.7 Increasing Quantity of Concentrates in Milking Robot……..…	22

3.8 Total Mixed Ration vs Partial Mixed Ration…….. 23

3.9 Automatic Feeding System vs Conventional Feeding System…… 23

3 Aim of Study……. 24

4 Materials and Methods…… 25

4.1 Dairy Farms location and environmental exposure…… 25

4.2 Animal Treatment and Farm Infrastructure……... 26

4.3 Genetic Make-Up and Water Supply…… 28

4.4 Gathering of data and result setup…… 28

4.5 Feeding Regime...……...……. 30

4.6 Limitations of the Study……..... 32

5 Results……... 34

6 Discussion …… 39

7 Summary……... 42

8 Bibliography……. 43

9 Acknowledgements……..... 48

1 Introduction

Holstein Friesian cattle are the world's number one breed in the dairy industry. Typically, all dairy farmers feed their cows a combination of forage along with concentrates. Different feeding regimes can bring about different performance results which may alter a farm's productivity and quality of product. Hence, this study reviewed the effect of maize silage introduced in the feeding ration on milk quantity. Additionally, the impact left by ryegrass silage compared to maize silage was also compared. A comparative analysis was done by using two dairy farms located in Malta, thus experiencing similar climatic conditions. Nevertheless, one farm was ill-equipped to withstand the dry and hot Maltese summers. Therefore, cow performances were not well maintained throughout the summer months. Thus, climate and nutrition both can have a significant impact on milk production of dairy cows.

In this study, milk production results were gathered from July 2023 until July 2024. Results were only gathered from cattle in their second lactation onwards in order to reduce discrepancies in milk production results when including first lactation cattle.

2 Literature Review

This chapter reviews multiple literature dealing with different dairy cow feed regimes and their impact on milk production and compounds. Studies have been conducted by a number of researchers over the years. The first five chapters (Chapters 2.1 to 2.5) highlight the effect of the number of meals given per day to dairy cows and the effect on milk yield and compound values. The following chapters (Chapters 2.6 to 3.4) focus on the addition of maize silage and its effect on the two main characteristics previously mentioned: milk yield and compounds. Throughout the entire literature review, one will note a variety of results sometimes even countering each other.

2.1 Effect of increased frequency in meals per day on the milk yield

Advancements in automated feeding equipment allow dairy cattle to be fed concentrates in small, frequent portions. Literature attempting to promote these automated feeding systems claim that more frequent feeding leads to higher milk production and a greater milk fat percentage [1]. One of the main aims of this study was to observe any changes in milk yield or milk quality with an increased feeding frequency. Gibson [2] conducted 35 experiments in Scotland on dairy cattle fed the same diet with one or more dietary components being offered at an increased feeding frequency. From this study, he concluded that, if a dairy cow is fed four or more times per day compared to once or twice a day, there will be an increase in the milk fat percentage by a proportional average of 7.3% and increased milk production by 2.7%. One also must mention that milk production was not affected significantly in 24 of the 35 experiments. Additionally, from these 35 experiments 27 of them, showed no significant difference in milk fat concentration. No significant changes were seen in milk protein and lactose concentration with an increased feeding frequency.

In the study carried out by French and Kennelly [1] in Alberta Canada, Holstein cows were cannulated inside their rumen and given a pelleted concentrated feed. Four of these cows were assigned to Treatment 1 which consisted of feeding pelleted concentrate in 12 equal portions at a two-hour interval. In Treatment 2, another four cows were given an equal weight of pelleted concentrates but this time it was split in two portions leaving an eight-hour gap between each feeding.

As seen in Table 1, the experiment showed a slight increase in milk production with an increase in feeding frequency. Furthermore, an increase of 0.39% in milk fat concentration was observed as the feeding frequency increased). [1]

Table 2.1 Milk Production According to Daily Feeding Frequency [1]

	Feeding Frequency	
	Twice daily	Twelve times daily
Milk yield kg/day	29.8	30.5
Milk Fat %	2.21	2.60
Protein %	2.84	2.84
Lactose %	4.67	4.67

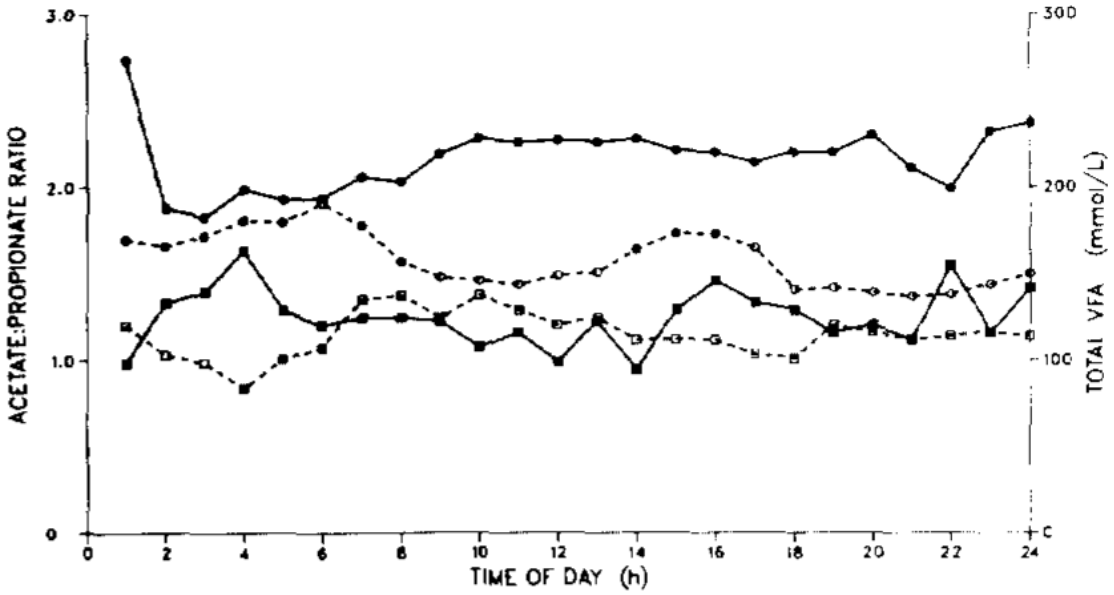
2.2 Effect of increased frequency in meals per day on milk fat concentration

In their research [1], concluded that, by increasing the feed frequency, the ratio of two volatile fatty acids (VFA's), acetate and propionate, increases. This increase in VFA's ratio with an elevated feed frequency can be seen in Figure 1. In research conducted by, [3] at the University of Arkansas USA, it was found that the higher the acetate levels in the rumen the higher the milk fat content. On the other hand, it was also found that milk fat content is negatively correlated with increased propionate and butyrate concentrations in the rumen.

Propionate is one of the main gluconeogenic precursors in ruminants [4]. [5] highlighted that insulin will then ultimately reduce the availability of gluconeogenic substances such as propionate for milk fat and protein synthesis. This is due to insulin playing an inhibitory role on gluconeogenesis.

[1] noted that the secretion of insulin is controlled by the level of VFA's in the blood which will increase if the cows are fed diets high in concentrates. This was especially observed, just after feeding time.

Figure 2.1 "Effect of feeding frequency on acetate to propionate ratios and total VFA concentrations. Acetate to propionate ratios; 2 times daily feeding (open circles, broken line) and 12 times daily (closed circles, solid line). Total VFA concentrations; 2 times daily feeding (open squares. broken line) and 12 times daily feeding (closed squares, solid line)" [1]



Glucose and Acetate storage is stimulated by the hormone insulin. These are particularly stored in adipose tissue. Thus, the mammary gland will not have glucose and acetate available for milk fat synthesis. If the feeding frequency increases, the sudden increased surges in blood insulin concentration may moderate. As a result, an increase in milk fat synthesis by the mammary gland will be observed.

From this research, one can gather that if feeding frequency increases, blood insulin levels are better maintained and controlled. As a result of this, due to increased ability to perform milk fat synthesis, a higher concentration of milk fat in the end product is observed. [1]

2.3 Variation in milk production results by other conducted studies

Different results about the influence that feeding frequency has on milk yield have been observed, from research done after the study mentioned by [2] in 1984. Studies performed by [6] and [7] show that the increase in feeding frequency increased the dry matter intake (DMI) of the total mixed ration (TMR). Despite this, it had no effect on milk production. As opposed to these results, another study by [8] show that the DMI and milk productivity increased when the cows were fed once a day compared to being fed more frequently. One also has to consider that in the study performed by [6] and [7], the cows were stanchioned. On the other hand, in the study by [8], the cows were kept in a free-stall barn. Different housing systems can easily impact the feeding behaviour thereby influencing the effect of feed frequency on the cow's milk productivity. [9]

In an experiment conducted in Finland by [10] an identical TMR was given to forty Finnish Ayrshire cows. The diet consisted of grass silage and concentrate mix. Cows undergoing different treatments were separated in different compartments. The cows were split in two groups. FF1 group was fed once daily at 16:00 hours whilst the FF5 group were fed 5 times daily at 08:00 hours, 13:20 hours, 14:30 hours, 18:00 hours and 19:40 hours. Cattle in the FF1 group were calmer as they were not continuously disturbed by feed delivery. As a matter of fact, they spent more time lying down than cows in the FF5 treatment. From this study [10] noticed that there was no difference in milk yield between both groups. Milk fat and protein content were also not affected by a change in the feeding frequency.

In a study set up by [8], it was observed that cows with a lower feeding frequency tended to increase in their DMI. This was linked to a more relaxed behaviour whilst feeding in the feeding passage and a longer period spent lying down and ruminating. On the contrary to the previously mentioned study by [10] an increased consumption of feed with lower feeding frequency was linked to an increase in milk yield. An increase in milk fat concentration was also observed when cows were fed with a lower feeding frequency. Increasing the feeding frequency in this case did not result in greater milk productivity.

"The disturbance caused by feeding cows four times daily reduced their milk production, and that of other cows housed with them that were only fed once daily, when compared with cows that were fed once daily by themselves". [8]

Recent studies show that overall, there is no effect on milk protein, fat or milk production with an increase in feeding frequency. In research performed by [11], it was concluded that

there was less leftover food for cows being fed three times daily thus they were consuming more dry matter (DM) on a daily basis than those being fed once or twice daily. Nevertheless, the feeding frequency did not influence milk production or milk compound results. Therefore, it was concluded, that the nutrients obtained from a higher dry matter intake were being metabolized for storage instead of being utilised for milk synthesis.

2.4 Impact of feeding frequency on milk productivity of cows in heat stress

During the summer months, higher milk yields were noted in cattle fed three times a day instead of twice daily. [12], confirmed this in an experiment analysing the effect of feeding frequency on milk productivity. This study was performed in the Czech Republic where the average summer temperatures are way below the high temperatures recorded in Malta [13].

Figure 2.2 Maximum and minimum temperatures in Prague (Czech Republic) 2024, along with the monthly average temperatures. [14]

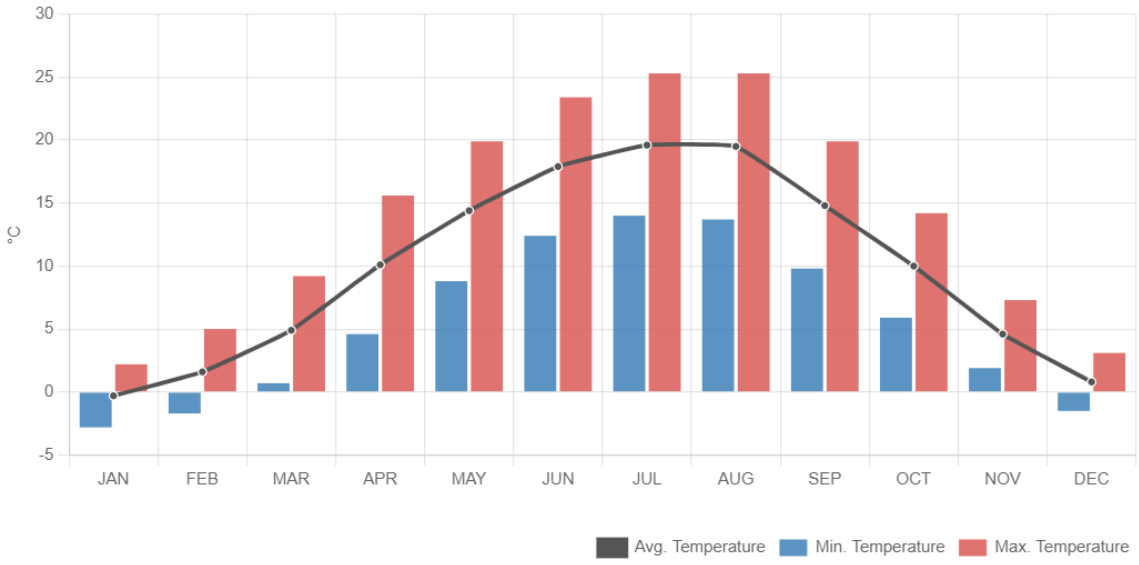
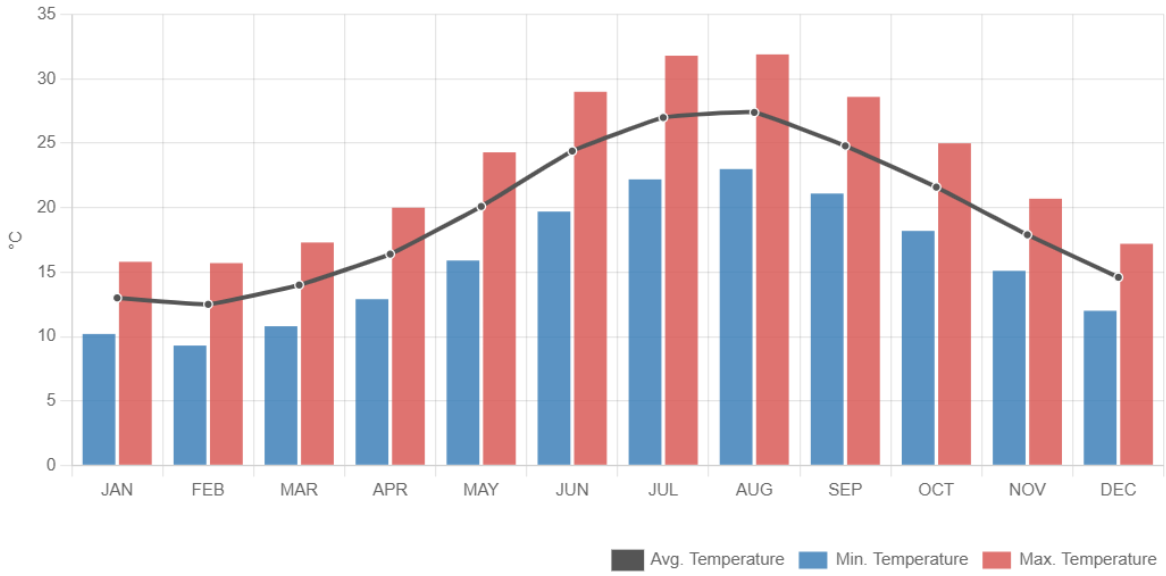


Figure 2.3 Maximum, minimum and monthly average temperatures in Luqa (Malta) 2024. [13]



This was not the case with a study performed in Italy by [15]. In this study increased heat stress on cows being fed once daily in the morning was confirmed due to exhibiting higher rectal temperatures 38.97 °C compared to 38.68 °C and 38.62 °C in the other two groups, and breathing rates (71.44 breaths per minute versus 66.52 and 65.26 breaths per minute). Additionally, morning plasma glucose levels were lower in morning-treated cows (3.69 mmol/L compared to 3.83 mmol/L in both morning/evening and evening-treated cattle)

No difference was observed in milk yields or milk composition with a change in feed management. Cows being fed the TMR once a day in the morning experienced the greatest heat stress when compared to the other two groups being fed once in the evening or twice daily. This particular case shows that, the feed management only influenced the animal welfare of the dairy cows. Whilst in terms of milk productivity and composition there were no considerable changes. [15]

2.5 Effect of feeding dairy cows at delayed stage compared to feeding straight post milking

Delivery of fresh feed impacts meal patterns and tendency to lie down after milking [16]. It is also well known that cattle will spend a longer time standing when feed is delivered shortly after milking [17].

In a study by [18], cattle being fed and milked twice daily with a feeding delay of six hours shown an increase by 12.5% in daily feeding time. During the same study it was noted that cows being fed at a six-hour delayed period spent twenty minutes less standing post milking compared to cows being fed shortly after milking. The downside of this is the increase in potentially acquiring intramammary infections due to the teat canal reaming open for around thirty minutes after milking. [19]

In an experiment designed by [20] in Canada, cows were split into two groups of six. Each cow in both groups was assigned to two treatments in a cross over model. In treatment 1, the cattle were fed soon after milking, twice daily. Whilst in treatment two the cows were fed with a delay of three and half hours from the milking procedure. From this experiment no difference was observed in total time spent feeding between the two treatments. In both treatments the DMI increased after every milking, but it was evident that cattle being deprived of fresh feed for a longer time post milking did not reach the same DMI as those in the first treatment (fed straight after milking).

It was noted that cattle consumed feed at a slower rate when they were fed at a delayed time from milking. The only point in time at which the feeding rate of cows, fed at a delayed stage increased more than cows undergoing the other treatment was at 17:30 hours. Apart from an increase in feeding rate for cows fed directly after milking time, these cows also had a larger sized meal and spent a longer time eating after the 14:00 hours and 07:00 hours milkings. No difference was seen between cow treatments after milking at 21:00 hours in terms of meal size and length of feeding time.

Overall, this study showed no great differences in average meal sizes and feeding times from 14:00 hours to 12:00 hours the next day when comparing cows from the two groups. Another observation made was that cows did not sort their feed for long or against long particles when fed with a delay. The opposite occurred when cows were fed straight after milking, as the sorting of particles occurred. Only a difference in the sorting of long particles was seen. There was no difference in sorting between treatments for medium, short, or fine particles.

Feed refusal rates, rumination time and lying time were all similar in both treatments. Cows withheld from feed after 14:00 hours and 07:00 hours tended to stand for a shorter time following milking. However, no difference was seen in both treatments at 21:00 hours milking when comparing latency to lie down.

Milk fat content came out slightly higher for cows fed at a delayed stage post-milking. Only a 0.2 % increase in cows fed directly post-milking was noted between the milk protein content of both treatments. These results showed that any delays in mealtime do not impact milk components.[20]

2.6 Corn silage characteristics

Corn silage is a forage which is high in energy and low in protein. It is frequently used to grow and finish off beef cattle, for calf production, growing dairy heifers and for lactating dairy cows. It is usually given together with a high protein forage such as alfalfa hay. [21]

Each maize silage will have different characteristics according to crop maturity, chop length, procedures during silo covering and even a change in climatic conditions. As referred to in Table 2.2 characteristics that may vary in corn silages include dry matter percentage, acidic detergent fibre, neutral detergent fibres, starch, ash and crude protein. 32 corn silages were analysed to compare the previously mentioned characteristics. [22]

Table 2.2 Average Chemical Characteristics of 32 Corn Silages. [22]

Nutritional Profile	Units	Mean
DM	%	34.7
ADF	%	26.9
Amylase Treated NDF	%	44.2
Starch	%	25.2
Crude Protein	%	7.8
Ash	%	5.1
Mean Particle Size	mm	4.2

The energy input is usually the main factor effecting the animal's performance. This is affected by both the dry matter intake (DMI) and concentration of energy. Generally, the digestibility decreases as the DMI increases. This is due to reduced retention time of feed in the gastrointestinal tract thus allowing less time for proper digestion. Neutral Detergent Fibre (NDF) and starch content also influence the digestibility. An increase in NDF content of forage brings about a decrease in DMI, this goes hand in hand with the theory that an abundance of fibre in the gastrointestinal tract inhibits DMI. The concentration of NDF of corn silage is on the lower end when compared to other grasses, this is due to its high grain concentration. [21]

2.7 Positive impact of maize silage on lactating and dry cows

Research performed by [23] in the Kilimanjaro area of Tanzania, established that with an increase of maize silage in the TMR brought about increased milk yields together with an increase in milk protein content. In this experiment, three different diets were given to 16 dairy cows in their second lactation. The first diet included maize stover, green forages and concentrates. The second diet constituted 25% maize silage, maize stover, green forages and concentrates. The third diet was identical to the second but with 50% maize silage instead of 25%. Results showed that cows being fed on the first diet had a mean milk yield of 10.27 litres. This increased to 11.28 and 12.92 with diets two and three respectively. The diets had no significant effect on the milk fat content. No significant change was potentially seen due to the high fibre content in the maize stover and the quantity of grain in the maize silage

Apart from lactating cattle, maize silage is also a great choice of forage for cows three weeks before calving (during the last weeks of their dry period). [21] During this period most of the cow's energy is absorbed by foetal development. [24]

Thus, since maize is high in energy it is of great value for the cow during this period. Generally, the DMI before calving sharply decreases. Consequently, there is more mobilization of energy reserves resulting in hepatic lipidosis. Since corn silage is highly palatable, it might aid in preserving a decent DMI. Apart from being palatable, maize silage is also highly fermentable. This helps the rumen microbiota, and ruminal papillae adapt to high grain diets fed soon after calving. [21]

One of the main advantages of feeding maize silage during the dry period is that it contains lower potassium and calcium levels than most other forages. During the dry period, most of the calcium is being utilized for foetal development inside the cow's uterus. A substantial amount of calcium is also used for colostrum production which will be vital just after calving. A low blood calcium level will bring about milk fever therefore the goal is to maintain blood calcium levels throughout the dry period and post-calving. [25] This is usually achieved by giving the cow feed that is low in calcium during the dry period. [26]

In this case, corn silage is beneficial as other forages, such as alfalfa, are high in calcium. Calcium levels must remain low during this time to prevent parathyroid hormone hyperstimulation. Additionally, the acid-base status is altered as a result of high potassium diets, causing prevention of calcium mobilization from bone. Therefore, one can conclude that corn silage impacts metabolic disorders during the cow's dry period which would definitely have an effect on the cow's milk productivity and ultimately resulting in an economic loss to the farmer. [21]

2.8 NDF and starch proportions in silage and its effect on milk production

NDF content, digestibility and particle size all influence milk productivity, rumination, mastication and intake of fibre. Cows will spend more time eating when the fibre content of their diet is high. On the other hand, as the NDF increases one can note the chewing time per unit of NDF diminishes. Chewing behaviour is influenced by the physical properties of the silage such as particle size, fragility and breakdown of particles. From a chemical point of view, moisture content, lignin and NDF content all have an impact on the chewing

behaviour. [27] [28] noted an increase of 1.8 h/d in eating time when forage content increased from 40 to 70% (mixture of corn silage, alfalfa hay, oat hay, and rye hay). Time spent ruminating was also elevated by an additional 35 minutes per day. The downside was that the resting time decreased by 2.3 hours per day, therefore the increase in time spent eating was taken from resting time.

Efforts to improve the NDF digestibility are associated with a decrease in lignin due to being an indigestible fibre. The maturity of the crop at harvest and additive treatments also can improve the NDF digestibility of silages. [27] [29] observed an increase in DMI and milk yield when cows were being fed a diet with better NDF digestibility. Sorghum silage, for example, has greater NDF and lignin values than corn silage. Hence it will decrease chewing duration resulting in reduced digestibility. One also has to point out that as reported by [30] cows eating sorghum had a higher milk fat content, but their milk protein was lower. Regarding milk yield and feed intake, no differences were observed.

"On average 42% of the NDF is digested in the rumen and 7% post-ruminal, while 51% is excreted in the faeces." [31] [31] remarked that an average ruminal NDF degradation of 32% was observed, whilst 7% was digested in the post-ruminal tract. [32] stated that post-ruminal digestion generally makes up 0 to 20% of the entire tract NDF digestion. As previously stated, lignin content together with maturation and cell wall thickness can all be a causing factor of a decreased NDF digestibility.

When it comes to starch, it is the main source of metabolizable energy in maize silage. It also provides energy for the ruminal microbial activities necessary for the fermentation of feed. Starch concentration in silage also has an effect on digestion, feed intake and ultimately milk production. The level of starch varies according to the time of harvest and growing conditions. Silages having a higher proportion of starch increase the propionate found in the ruminal fluid eventually leading to an increase in VFA found in the blood. One must be aware that if the level of VFA's circulating is too high it can easily lead to a feeling of satiety, leading to a rapid decline in DMI and decreased milk production. Therefore, starch concentration in silages including corn silage must be controlled. [33]

Starch can be digested in both the rumen and intestines although this usually depends on the starch composition which is affected by the genotype of the maize, conditions during growth and stage of maturity. The site of starch digestion has a variety of impacts such as

loss of microbial matter when it is digested in the large intestines, ruminal health and pH and milk fat composition. [27]

2.9 Replacing grass silage with maize silage as main dietary forage for dairy cows

When including maize silage as forage in grass-silage-based diets [27], noticed that there was an increase in DMI by 2kg per day. An increase in milk yield by 1.9kg per day and the milk protein content by 1.2g per kilogram was also noticed. The milk yield peaked when 50% of the average energy obtained from grass silage was substituted with maize silage. During this study, the same concentrate was used in all the diets. As a consequence of an increase in maize silage being introduced the crude protein dietary content slowly decreased. The peak DMI and milk production was achieved at a point when 75% of the grass silage was replaced with maize silage. [27]

One must mention that due to the limited DMI obtained by dairy cows from grass, the energy needed for milk production cannot be supplied by grass intake by itself. [34] According to previous studies done by [35] and [36] rye silage has shown that it yields similar DMI and milk productivity as corn silage, sorghum silage, or wheat silage.

In contrast to this, an experiment conducted in the USA by [37] showed different results which highly favoured use of ryegrass silage rather than maize. This experiment was performed on twenty Holstein cows which were initially fed corn silage and alfalfa as forage ad libitum. This diet was kept for a period of two weeks after which each cow was then randomly assigned to one of four experimental diets. Ryegrass substituted corn silage gradually along the following four experimental diets as seen in Table 2.3.

Table 2.3 Forage being used in TMR [37]

Experimental Diet	Maize Silage percentage (%)	Rye Silage (%)
Diet 1	100.00	0.00
Diet 2	65.00	35.00
Diet 3	35.00	65.00
Diet 4	0.00	100.00

Results from this experiment showed that the milk yield significantly increased as the proportion of rye silage increased. Milk fat percentage was at its highest when cows were

given diet two or four as suggested by Table 2.3 above. Protein values were similar throughout all the different diets. [37]

3.0 Replacing ryegrass with other forages

[38] suggested that greater DMI, milk yield and milk protein concentration were achieved with corn-silage-based diets rather than with ryegrass-based diets. DMI obtained by cows from ryegrass tends to be low compared to other forages. This is due to the high moisture content found in grass silages which is typically ranging from 65 to 75 percent. [39]

An experiment conducted in Moorepark Research Centre Ireland, sought to find whether ryegrass silage was inhibiting or optimizing the performances of dairy cattle when compared to other forages. Cows were randomly categorized in four different groups in which each group was fed a different forage. Forage 1 consisted of grass silage as the only forage. Forage 2 consisted of a blend of grass silage together with fermented whole-crop wheat. Forage had grass silage mixed with urea-treated whole-crop wheat and Forage 4 had a blend of grass silage together with corn silage.

Results of this experiment showed that milk productivity and nitrogen utilization mainly increased when corn silage was included in the ration mixed with grass silage rather than when other forages were mixed with grass silage. Milk protein concentration was lowest when grass silage was fed as a sole forage. Protein concentration increased when the other forages were also introduced in the TMR. In terms of milk lactose and fat, no significant difference was found between each forage treatment. [40] Many studies show that when grass silage is given along with other forages the dairy cow performance improves. [41]

3.1 Effect of DM content of corn silage on milk yield, and composition

[42], during their study in Wisconsin USA, concluded that, with an increase in the dry matter content of maize silage the milk yield, protein and fat concentrations all decreased. The highest milk production was achieved when the DM percentage of the corn silage was between 28.1and 32.0 %. Just as the DM percentage reached 32.1% the milk productivity, fat and protein concentrations started declining. Milk urea nitrogen stayed relatively the same as DM percentage of the maize silage increased. Despite this, it slightly increased when the DM percentage was greater than 40.0. [42]

3.2 Changes in maize silage components at different stages of maize crop maturity

[27] noted that, when corn silages were harvested and ensiled at an early stage, dry matter intake, milk yield, and milk protein content were recorded at their lowest point. As the maize crop matured further the DMI, milk yield and protein content increased. As the DM content of the maize increased more than 350g per kilo, the milk production, protein and DMI all started declining. This evaluation of the effect of maturity on maize silage was based on ten studies with multiple selected comparisons. In each of these studies, three maize silages were harvested at different maturity stages. A low DMI of the maize silage may have been linked to a high content of NDF and a very low amount of starch. This would be the case when the corn was harvested and ensiled at a very early mature stage. In this study, it was found that there is a positive relationship between the starch content of silage and its DMI, whilst one can note a negative relationship between NDF and DMI. As the maturity of the crop increases the DM and starch start to increase whilst the NDF and CP contents decrease. The reason for a decrease in NDF alongside progressing maturity is due to a faster increase in DM content than NDF in the stover.[27]

3.3 Maize silage effect on DMI, milk yield and fat in dairy cattle and buffaloes

Eight dairy buffaloes and eight dairy cattle were used in a study conducted in Nepal in order to compare the effect of dry matter intake and milk productivity with an increase in maize silage consumption substituting rice straw as roughage.

The animals were subject to four different dietary treatments. The first diet was only composed of rice straw and concentrates. In the second, third and fourth treatments, the rice straw was slowly reduced and substituted with maize silage at a steadily increasing percentage, until the last treatment was composed of 100% maize silage as roughage. This transition from rice straw to maize silage can be seen in Table 2.4.

Table 2.4 Percentage of Maize silage as forage in each dietary treatment [37]

Treatment	Maize Silage as roughage %
1	0.00
2	33.00
3	67.00
4	100.00

Very slight differences were observed between the results of these two species. The intake of roughage increased in buffaloes as the percentage of maize silage increased. Despite this in the 4th treatment the roughage intake decreased again when maize silage was the sole roughage in the diet. Cattle responded identical when comparing roughage intake. Milk yield in both cattle and buffalo steadily increased as the maize silage levels were increased. In cattle the milk fat concentration was at its highest during the first and 4th treatment. On the other hand, peak milk fat concentration in buffalos was reached in treatment 4.

This study showed that substituting rice straw with maize silage leads to higher milk yields and fat concentrations. High maize silage levels in the diet also increase dry matter intake until the maize silage alone is fed as a forage. [43]

3.4 Replacing maize silage with an alternative forage in water-limited regions

Despite maize silage being one of the top forages used on dairy farms it requires high water uptake which is far from ideal in dry and hot climates. [44] Such climates are typical to the Mediterranean basin including Malta. [45] Sorghum silage can provide a good alternative in such conditions as it has a greater resistance to drought. [44] The sugar found in sweet sorghum silage can also provide the necessary amount of starch as that found in maize silage. [46]

Three different forages were given as part of the TMR of twenty-four dairy cows to evaluate the effects on milking performance, milk compounds and digestibility. Maize silage, high-sugar sorghum silage and forage sorghum silage were used as the three different forages. In this study, all the cows were Chinese Holstein producing a similar milk production and having roughly similar bodyweight. The cattle were then split into three groups of eight in

order to undergo different dietary treatments. Each cow was fed a TMR consisting of either 40% maize silage (MZS), 40% high sugar sorghum silage (HSS) or 40% forage sorghum silage (FSS). All cows in this study were fed ad libitum.

Maize silage when compared to HSS and FSS had a higher starch value. However, water-soluble carbohydrates were higher in HSS than MZS and FSS. HSS and MZS both had a higher crude protein content than FSS whereas their NDF and ADF were lower than those of FSS.

An HSS forage-based diet showed the highest amount of milk production. Milk fat was roughly equal in all diets. Protein content was highest when feeding MZS. The highest lactose content was achieved with the HSS diet. From these observations, one can conclude that feeding sweet sorghum silage as forage instead of maize silage would result in very similar production results.[46]

3.5 Increasing the NDF of maize silage

[47] proved that starch escaping ruminal degradation provides more energy when it is digested in the small intestine. Maize contains a high content of starch which can escape from ruminal digestion too. Ruminal degradation of maize starch occurs at a slow rate when compared to other cereals such as wheat, oats and barley [27] . The process of ensiling has proved to increase the rate of ruminal degradation of starch [48]. As a result, this causes a higher starch digestibility for maize silage than for fresh maize crops [49].

Cell walls are composed of structural carbohydrates (plant fibre), which are the main source of energy for forages [50]. When the neutral detergent fibre (NDF) is in excess, it limits feed intake as it contributes to a more fully packed rumen. The amount of feed intake is important for milk productivity, but the NDF digestibility is also of utmost importance. [51]

Increased level of NDF digestibility was linked with an increased crude protein concentration. In contrast to this, the concentration of dry matter and starch decreased with a higher NDF digestibility of maize silage. Additionally, milk production, lactose concentration and daily weight gain were enhanced when the NDF digestibility of maize silage increased. The NDF level of the maize silage is highly affected by the maize crop

maturity at harvest. [52] The more the maize crop is allowed to mature the lower the NDF content. [27]

3.6 Automatic Feeding System and Robotic Milking

Thanks to milking robots' individual management of dairy cows can be better maintained. Feed can be provided by milking robots along with the basic ration given in the feed bunk without limiting milk productivity. With robotic milking and feeding systems, cows can be fed according to their individual productive performance. [53] Due to automatic feeding systems being easily programmable an increase in feeding frequency is facilitated. [54] Three studies were performed in North America to evaluate the performance efficiency of automatic milking systems. [55]

From data gathered in these three separate studies, it is evident that cows were milked on average three times per day. Cows, end up getting milked more often when using a milking robot whilst also producing more milk. [56] Additionally, it was found that the amount of offered concentrates in the robot was positively related to daily milk production. Authors of this study stated, that when increasing the number of concentrates given per cow, individual milk yields improved. [55]

3.7 Increasing Quantity of Concentrates in Milking Robot

Research Saskatoon in Canada was conducted in order to explore whether an increase in quantity of concentrates in the milking robot, leads to increased milking frequency. In the study by, [57] it was noted that no change in milking frequency was seen with an increase in concentrates being provided within the milking robot. Similarly, [58] found that the total DM intake and milking frequency were not affected by a change in concentrate quantity put within the milking robot. The only change noted was, that cows consuming a higher quantity of concentrates in the robot consumed less food from the feeding bunk. In another study, [59] tested four different amounts of concentrates offered within the robot. Yet again the total DMI and milking frequencies were not affected by varying concentrate quantities. [55]

3.8 Total Mixed Ration vs Partial Mixed Ration

Feeding a cattle TMR means combining feeds such as forages, grains, vitamins and minerals together with any feed additives in one feed ration. The disadvantage of this specific feeding regime is that all the cows in the herd are fed the exact same ration and individual feeding is impossible. In order for TMR feeding regime to be used effectively, cows must be grouped according to milk productivity and body weight. [60]

Partial Mixed Ration (PMR) is adjusted individually according to each cows' dietary requirements. For example, cattle having higher milk yields will be getting more concentrates to provide them with the necessary nutritional support for such high milk yields. Generally, the PMR is based on five to seven litres less of the average milk production performance. This is done to stimulate the cattle to search for more feed, which they will find within the milking robot. [56]

3.9 Automatic Feeding System vs Conventional Feeding System

22 dairy farms in the Netherlands using an automatic milking system were used in a study to compare automatic feeding system (AF) versus the usage of a conventional one. Hence, the farms were divided into two groups, one using an AF system and the other group using a conventional feeding system (CF). Herd sizes and milk yields of both groups of farms were similar.

Holstein Friesian was the main breed found on all these farms. It was noted that farms using an AF system produced 8900kg per cow per year whilst CF farms produced 8705kg per cow per year. Furthermore, the top milk yields (10,000kg per cow per year) were mainly found in higher numbers in AF system farms when compared to CF system farms.

A higher feeding frequency was recorded in AF system farms rather than conventional ones. The total amount of daily DM offered to cows in both groups of Farms was very similar. AF farming systems offered 42.6kg per cow whilst CF systems offered 42.2kg. On the other hand, a difference in feed leftover at the feed bunk was noted as AF farms had an average of 1.5% daily feed quantity as leftover whilst CF farms left 3.2% as leftover from their feed. [54]

3 Aim of Study

The aim of the study was to assess the effect of introducing maize silage on the milk yield of dairy cows in their second lactation onwards. A comparison between a feeding ration including maize silage versus ryegrass was also studied.

4 Materials and Methods

4.1. Dairy Farms location and environmental exposure

Across Malta and Gozo there are 79 dairy farms all supplying milk daily to Benna Malta Dairy Products Ltd. The quality and assurance of milk production on the island is regulated by Kooperattiva Produtturi tal-Halib (KPH). I explained the aim of my study and KPH initially suggested two farms having approximately the same number of cows and very similar farm conditions. The only difference was that one had just introduced maize silage in the TMR. However, after having collected data for two months, the control farm withdrew from the study. Due to ethical reasons, all data collected from this farm had to be discarded. KPH provided me with another farm that was willing to participate in this study. This farm was selected by KPH since its feeding regime did not include any maize silage. Milk yield results were collected by the farmers of both farms over a twelve-month period. A description of both farms follows.

Farm A located in Ħal-Għaxaq (66 metres above sea level) houses 94 dairy cows in an area of 3,724.9m^2 whilst Farm B is located in San Ġwann (90 metres above sea level) houses 45 dairy cows in an area of 1,262.18m^2. A small distance of eight kilometres separated these two farms. Both sets of cattle on each farm experienced the same characteristic Maltese climate throughout the year. On average such a climate consists of a relative humidity of 73%, rainfall of 592mm, and a wind speed of 9.1 mph per year. Typical Mediterranean temperatures were also experienced, meaning dry and hot summers together with mild wet winters. The average daily maximum temperature is 23 degrees Celsius. Nevertheless, during the summer months, this increases up to 32 degrees Celsius [45].

4.2 Animal Treatment and Farm Infrastructure

All cows used in this experiment were of the same breed, that being Holstein Friesian. Cows considered for the study were from the second lactation onwards. Milking of cows on Farm A occurred at 06:00 hrs and 17:30 hours in a side-by-side parlour using milking clusters. Cows in Farm B enter the milking parlour on their own and are milked by using a Fullwood Merlin electric milking robot.

Figure 4.1 Side-by side milking parlour

Figure 4.2 Fullwood Merlin milking robot

Farm A feed their cattle three times daily at; 06:30 hours, 12:00 hours and 18:00 hours. Farm B feed their cattle twice daily at 03:00 hours and 15:00 hours. Both farms use sawdust for bedding and house their cattle in a free-stall barn. Both sets of farmers make sure that water is constantly available in the water troughs throughout the entire day.

Overall, on both farms, the roof material was made up of metal on top of which photovoltaic panels were attached. On Farm A half of the farm had a concrete ceiling rather than metal. Both farms have great ventilation across the entire farm. However, during on-site visits, it was observed that Farm B has better cooling systems as it also has water sprinklers installed and a total of twelve fans. Nine of these fans were positioned at an angle facing the cattle and another three were attached close to the ceiling placed in horizontal fashion, thus cooling the air above. Additionally, these fans use sensors to increase and decrease the speed of the propellers according to the temperature in the barn. Farm A only had eight ceiling fans and no water sprinklers.

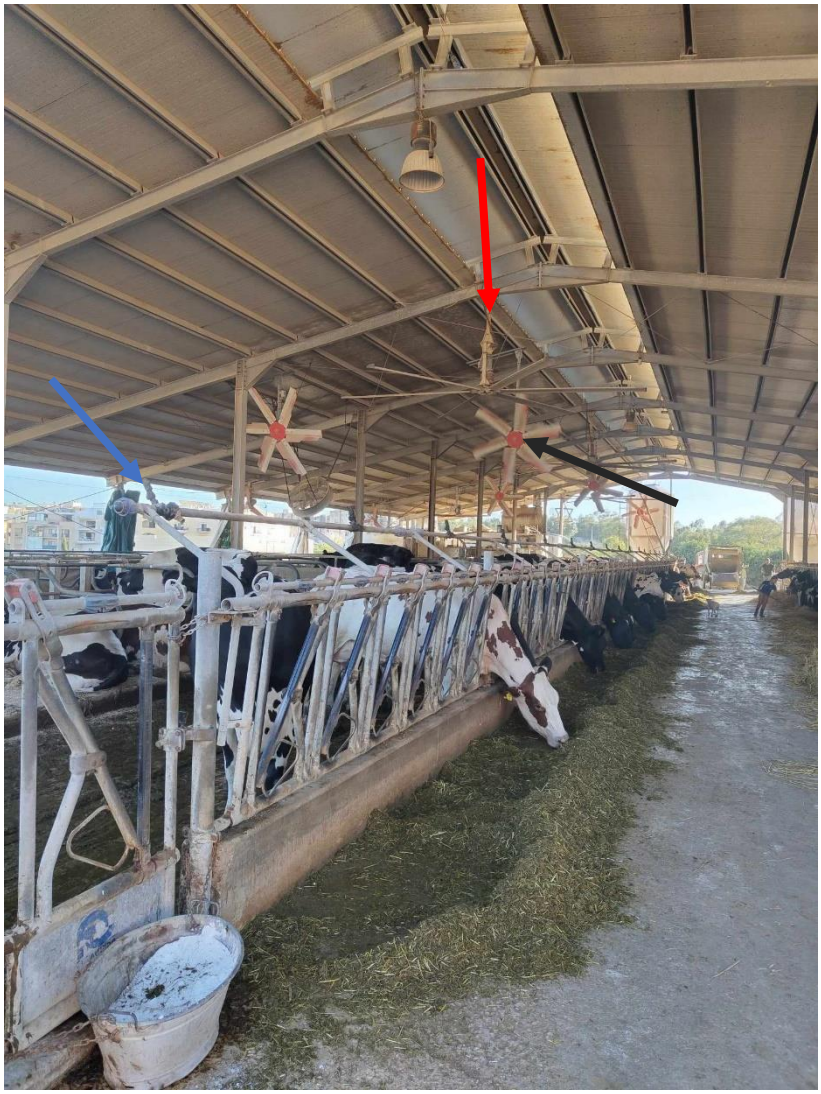


Figure 4.3 Blue arrow depicts one of the water sprinklers. Red arrow depicts one of the three ceiling fans. Black arrow depicts one of the nine fans positioned at an angle facing the cattle. (Farm B)

Figure 4.4 Ceiling fan found at Farm A. Metallic rooftop is also visible here. (Farm A)

4.3 Genetic Make-up and Water Supply

Holstein Friesian Cattle made up the vast majority of both herds on each farm. Semen used on either farm is supplied from the same cooperative known as KPH. Each farm was also supplied by a borehole as their water source. The days in milk (DIM) of both farms were in the range of 180-200 days. Concentrates given on both farms were identical and obtained from KPH Feedmill.

4.4 Gathering of data and result setup

Milk results were gathered from both farms during the last week of each month. Both farms had an identical system of milk data gathering. Each cow had a tracking device strapped on her left forelimb which was instantly detected once it entered the milking parlour. By the end of the month the farmers used to send me a photo of the milk production of all the milking cows. Results were provided once a month presenting milk produced in one day during every month. For this study, cows in their first lactation were eliminated.

After obtaining all the milk production results from July 2023 until July 2024, all these values were inputted into two Excel sheets (one for each farm). From these spreadsheets, tests were run to make certain that all the data was statistically significant. For this research, all statistical tests were carried out using the online application Statistics Kingdom. [61] The Shapiro-Wilk test was used for statistical analysis. This test confirmed whether the data was normally distributed. Q-Q plots and histograms were used to visualise this data. The Man-Whitney test Calculator and Paired T-tests were then run to determine whether the data and changes in data were statistically significant based on the normally distributed data.

In September 2024, I was in Malta and carried out an onsite visit to both farms as part of my research. It transpired that, whilst Farm A was feeding the cows a feed regime consisting of, alfalfa, hay, maize silage and concentrates, the mixture for Farm B included a mixture of, alfalfa, ryegrass and concentrates.

The conventional feeding method adopting a one size fits all approach when giving the TMR to the entire herd is the main method used in Malta on dairy farms. This system is adopted by Farm A. In contrast to this, during the onsite visit, it was revealed, that Farm B was in fact using an automatic feeding method and offers the cattle a partial mixed ration (PMR). Cows on Farm B have a pedometer which is detected by the milking robot during milking. The robot then adjusts additional concentrates alongside with propylene glycol according to the days in milk and milk yield of that specific cow. Propylene glycol is used for ketosis treatment as it stimulates gluconeogenesis whilst also increasing blood glucose levels and decreasing lipolysis. Propylene glycol is a precursor of propionate which is one of the main VFA’s used to obtain energy in ruminants. [62]

4.5 Feeding Regime

Table 4.1. Nutritional profile of the concentrates given on both farms.

Nutritional Profile	Percentage of nutrients (%)
Starch	46.00
Crude Protein	18.00
Ash	4.50
Fibre	4.50
Oil	4.00

Table 4.2 Feeding Regimes of Farm A and B

Farm A		Farm B	
Feed	Quantity in KG	Feed	Quantity in KG
Alfalfa	3.00	Alfalfa	3.00
Concentrates	15.00	Concentrates	14.00
Maize Silage	6.00	Rye grass	11.00
Hay	4.00		

Figure 4.5 Cross Analysis of two feeding rations (Figure taken from KPH Feeds Laboratory)

Farm A

Farm B

	Original					
Nutrient name	Daily intake	% DM	Requirement	Shortf	Daily intake	% DM
DM (kg)	19.6		22.3	-2.7	23.4	
DM DietCheck (kg)	19.61		19.69	-0.07	23.43	
Forage as fed (kg)	13.0				11.5	
Forage (%DM)	39				46	
Concentrate (%DM)	61				54	
ME (MJ)	223	11.4	220	4	280	12.0
ME (%req)	102				128	
Milk from ME (kg)	28.7				39.2	
Milk from MP (kg)	38.7				38.5	
Protein (g)	3931	20.0			4457	19.0
MP -N (g)	2856	14.6	1955	901	3149	13.4
MP -E (g)	2454	12.5	1955	499	2565	10.9
MP (limiting) (%req)	126				124	
MicrobialCP -N (g)	2124				2481	
MicrobialCP -E (g)	1493				1565	
Microbial CP (%N/E)	142				158	
DUP (g)	1502	7.7			1567	6.7
Starch (g)	6173	31.5			5302	22.6
Rumen Starch (g)	4983	25.4			4169	17.8
Sugar (g)	812	4.1			1304	5.6
Starch plus Sugar (g)	6985	35.6			6606	28.2
NDF (g)	5102	26.0			7974	34.0
NDF from Forage (g)	3634	18.5			5640	24.1
PE NDF (%DM)	9.7				16.9	
RSV	179		97	82	210	
Oil (AH) (g)	742	3.8			867	3.7
NFC (%DM)	43.5				34.3	

Farm A started to give maize silage to the herd a few weeks prior to milk data collection. Once a week, a trailer used to drop off maize silage coming from Italy at the farm. All the silage was stored in a cool, dry place and left wrapped up in a waterproof plastic sheet. The farmer stated that he tried to use all his stock of silage in one week in order to prevent it from getting wet, mouldy or damaged by other pests.

Figure 4.6 Maize silage used at Farm A

Figure 4.7 PMR given at Farm B depicted by blue arrow above.

Table 4.3 Nutritional Profile of Maize Silage being used at Farm A

Nutritional Profile	Percentage (%) of nutrients
DM	36.58
Ash	2.48
Crude Protein	6.56
Ether Extracts	3.19
NDF	38.25
ADF	17.71
Non-Fibre Carbohydrates	49.52
Starch	36.69

Maize silage being used at Farm A had a higher DM content than the suggested limit by [42]. Therefore, according to this study, it should yield less milk, protein and fat levels when compared to silages having a DM of less in the range of 28.1% - 32%.

4.5 Limitations of the Study

Only a handful of farms in Malta were available to cooperate for this study. Furthermore, one of the farms withdrew from this study and due to ethical considerations, these results could not be used. Following this, KPH recommended another farm referred to in this study as Farm B. However, at a later stage in the data collection, it transpired that the herds were kept in different conditions than those of Farm A. To minimize this limitation milk production data from both farms were collected during July 2023 and July 2024. The only variable for results obtained from Farm A was the introduction of maize silage in the feeding ration. On the other hand, no change was made to Farm B.

Unfortunately, farmers of both farms were not able to provide any data related to milk fat and protein percentages for this study. When I approached the head of KPH to ask for this data I was informed that in the Maltese context, all milk produced from all farms on the island is pooled. The milk processing plant then takes a sample from the combined

production to assess overall milk quality. As a result, the milk quality of both farms could not be studied, therefore, analysis of milk results can only be based on milk productivity.

Due to my studies in Budapest, I could not personally inspect both farms onsite and collect the data myself. Therefore, I had to rely heavily on the support of Farmers to obtain data and information.

Ideally, the entire study was conducted on the same farm in order for all the cows to experience identical conditions. One set of cows would then be fed ryegrass whilst the other set maize silage. Feeding frequency would also vary for each set of cattle. Unfortunately, this was not possible on dairy farms in Malta due to interruptions in their daily productivity and management systems.

5 Results

Outliers in the data collected from both farms were removed at the start of the statistical analysis to ensure the validity of the statistical tests that were to be carried out. Two outliers were removed from Farm B and four from Farm A. This was done as these six cows were producing extraordinarily low or high results compared to the rest of the herd.

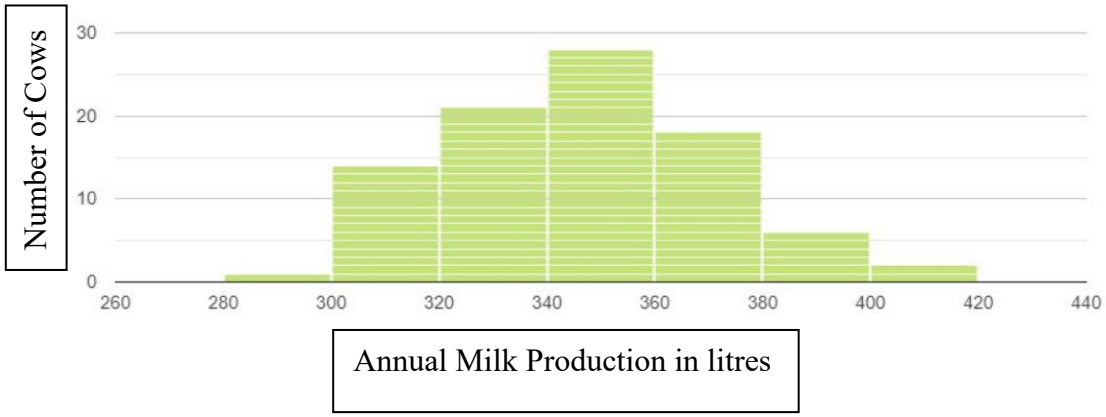
The Shapiro-Wilk test was then applied to test for the normality of the annual yield per cow from August 2023 up until July 2024. This was carried out, to check that data collected is distributed according to the normal distribution. Normality of data is required to carry out further parametric tests.

Table 5.1. Results of normality tests for annual milk yields of Farms A and B.

Farm	Mean	Standard Deviation	Sample Size	Skewness	Kurtosis	P-value
A	345.3933	24.59	90.00	0.29	0.72	0.74
B	384.2163	33.53	43.00	0.30	0.51	0.14

For both farms, since p-value is > 0.05 it is assumed that data is normally distributed. This is also evident from the visual tests below in Figures 5.1 to 5.3.

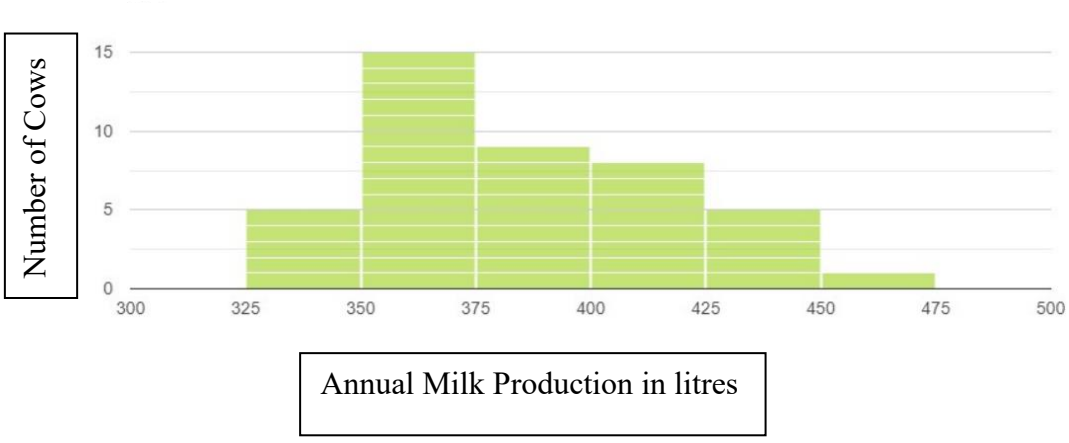
Figure 5.1 Histogram of Farm A presenting number of cows (Y-axis) vs Annual Milk produced in litres (X-axis)



[61]

P-value: 0.74

Figure 5.2 Histogram of Farm B presenting number of cows (Y-axis) vs Annual Milk produced in litres (X-axis)



[61]

P-value: 0.14

The visual tests above indicate that the cows the cows in Farm B are able to produce more milk than those of Farm A. Histograms 5.1 and 5.2 demonstrate that the cows yielding less milk of Farm B are producing much more milk than the lowest productive cows of Farm A. Similarly, the highest producing cows are found in Farm B where they reach up to 425-475 litres. Cows in Farm A do not manage to reach these figures. Most of the cattle in Farm B produce a minimum of 375 litres of milk annually. In contrast, the majority of Farm A are producing a minimum of 340 litres annually, thus being 35 litres of milk less per cow.

A Two-sample Mann-Whitney U test was then applied to compare annual yields of the two herds of cows. This test was done to confirm that the difference between the two farms is statistically significant. The results from this test can be seen in the table below.

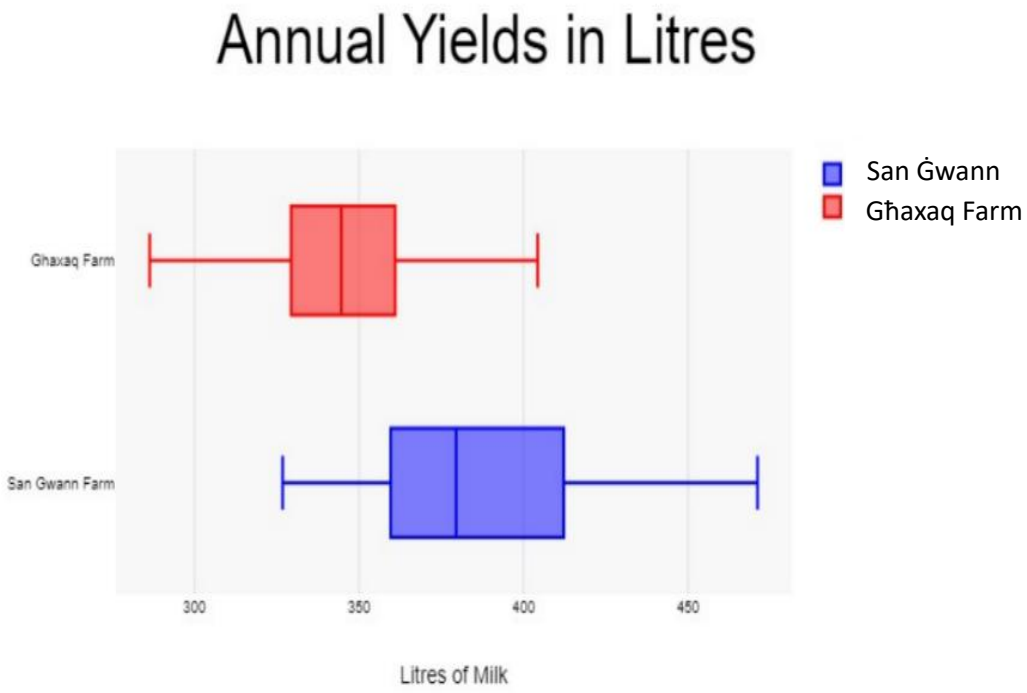
Figure 5.4 Two sample Mann-Whitney U test

Farm	Sample Average	Sample Size	Sample SD	Median	Normality	Skewness	P-value
A	345.39	90	24.59	344.70	0.74	0.30	0.00000000227
B	384.22	43	33.53	379.50	0.14	0.37	

[61]

Since p-value is less than 0.05, the difference between the randomly selected value of Għaxaq Farm (Farm A) and the San Ġwann Farm (Farm B) is large enough to be statistically significant.

Figure 5.3 Boxplot showing litres of milk produced by all the cows in both farms



[61]

P-value of San Ġwann Farm (Farm B): 0.14

P-value of Għaxaq Farm (Farm A): 0.07

The discrepancy in milk production can be best observed in Figure 5.3 above. The Lower Quartile, Median and Higher Quartile are much higher for Farm B than for Farm A. The upper 25th percentile of Farm B are producing more milk than the most productive cow of Farm A. From Table 5.1, the mean milk yield for Farm B was 384.21 litres whilst that of Farm A was 344.58 litres. Q1 of Farm B is 359.63 litres whilst Q3 of Farm A is 360.98 litres. Following this statement, one can note that cows in the lower quartile of San Ġwann's Farm yields approximately the same amount of milk as cows in the third quartile of Għaxaq Farm. Thus, this shows that the lowest-performing cows of Farm B are producing milk equivalent to the second-best performing cattle (Q3) of Farm A. Overall, 25% of the cows in Farm B produced more milk than those of Farm A Upon observation, it is also evident that the maximum yield of Għaxaq Farm (408.38 litres) is even less than the upper quartile of dairy cows of San Ġwann's Farm (412.2litres).

A number of factors could have attributed to such a result, the most salient being the usage of ryegrass in the feeding ration and the robotic milking system of Farm B. [27] [54] The better ventilation system and the feeding frequency could also have had a weighed on the results. [12] [15]

Since too many variables could have impacted the difference in the annual yield of the two farms (P-value = 2.27e-9) it became clear that one could not reach any conclusions as to whether the addition of maize silage increased the productivity of the milk yield. Following this, I requested data from both farms on the milk yielded in July 2023. Farm A had just introduced maize silage to the feed a few weeks prior to July 2023. It was decided to analyse the difference between the yields of July 2023 and July 2024. For the herd of Farm A all conditions remained stable except for the introduction of maize silage. For the herd in Farm B the conditions of July 2023 and that of July 2024 were the same. Any change in the milk yield for Farm A could thus be attributed to the introduction of maize silage.

6 Discussion

Once again, the Shapiro-Wilk test was carried out as shown in the table below for data collected for the months of July 2023 and July 2024 to check that data collected is distributed according to the normal distribution. Normality of data is a pre-requisite for the paired T-test.

Table 6.1 Shapiro-Wilk Test Normality test

Farm	Time of Year	Mean	Standard Deviation	Sample Size	Skewness	Kurtosis	P-value
A	July 2023	22.32	6.24	91.00	0.68	0.55	0.65
A	July 2024	25.65	7.91	90.00	0.46	0.78	0.06

As for the table above, since the p-value for the Shapiro-Wilk test is larger than 0.05 the data is assumed to be normally distributed. To check for statistical significance a paired T-test was carried out.

Table 6.2 Paired T-test comparing yield July 2023 to yield July 2024 of Farm A

P-value	Sample size	Average of differences	Standard Deviation of differences	Skewness	Kurtosis	Total Milk Yield July 2023	Total Milk Yield July 2024
0.00093	87.00	3.39	9.21	0.23	0.58	2083.3	2332.4

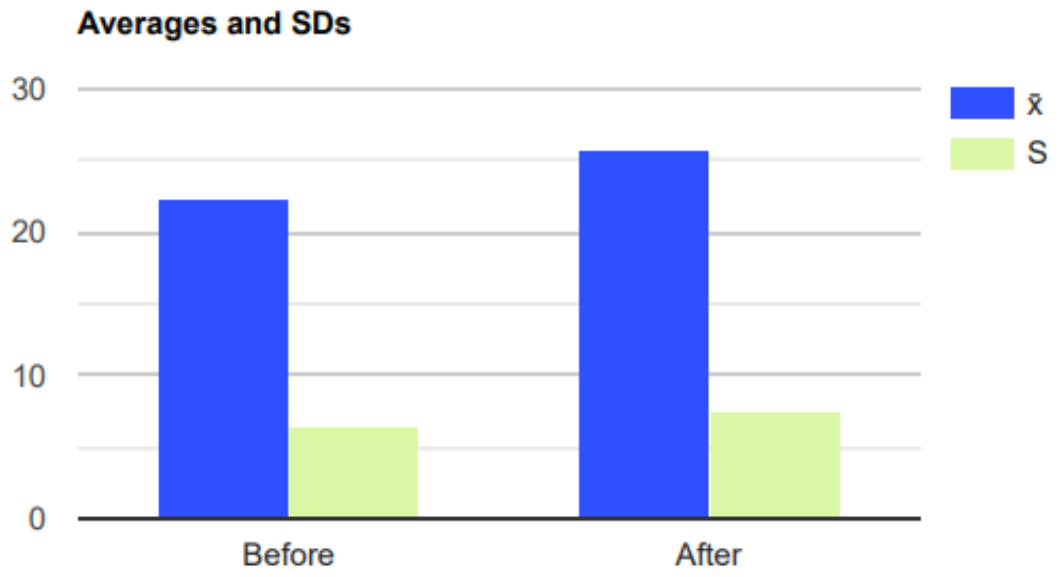
Since the p-value = 0.00093 (less than 0.05) the sample differences between the yields for Farm A is big enough to be statistically significant. The percentage increase in milk production per month is that of 11.96 %.

Table 6.3 Paired T-test comparing yield July 2023 to yield July 2024 of Farm B

P-value	Sample size	Average of differences	Standard Deviation of differences	Skewness	Kurtosis	Total Milk Yield July 2023	Total Milk Yield July 2024
0.56	43.00	-0.84	9.40	-0.33	0.34	1368.60	1332.60

Since the p-value is = 0.56 (bigger then 0.05) the sample differences between the yields for Farm B is not big enough to be statistically significant. The milk production remained stable.

Figure 6.2 Average and standard deviation of milk yields per cow in July 2023 vs July 2024. (Farm A)



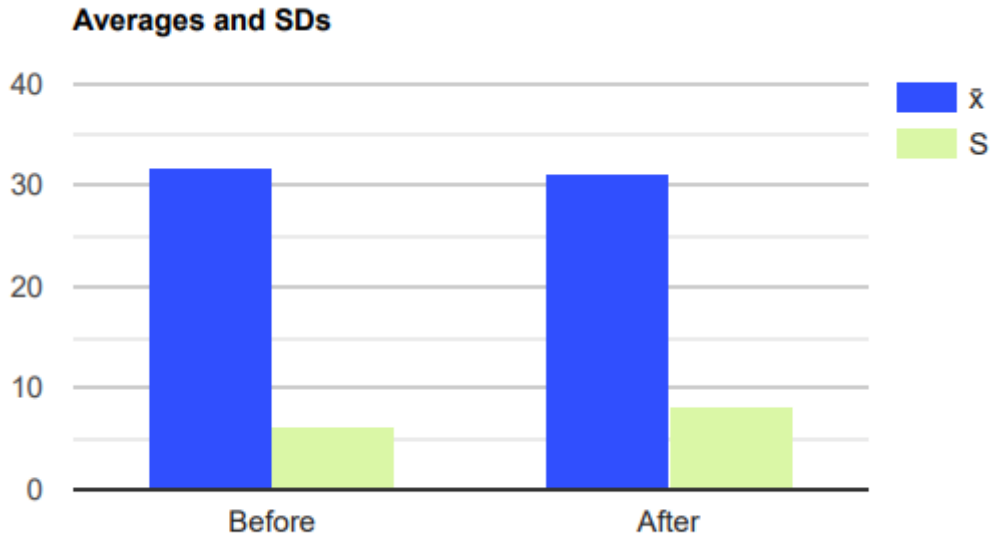
[61]

P-value: 0.00093

From the paired T-test, the P-value was that of 0.00093. This means that when comparing the two sets of data together a significant difference was found. The average difference in milk yields from Figure 6.2 is that of 3.4 litres. This means that there was an increase in milk production of 11.96% from July 2023 to July 2024. Therefore, maize silage potentially left

an impact on the dairy cow performances. Figure 6.2 shows that the majority of the cattle of Farm A increased their milk production in July 2024 compared to July 2023.

Figure 6.3 Average and standard deviation of milk yields per cow in July 2023 vs July 2024. (Farm B)



P-value: 0.56

[61]

In comparison to the paired T-test of Farm A, the p-value of Farm B's paired T-test is much bigger as it is 0.5624. This shows, that when the two sets of data of July 2023 and July 2024 of Farm B were compared, no significant difference was found. This concludes that Farm B kept on producing a constant milk production throughout the 12-month period whilst Farm A saw an increase of 11.96% in milk production.

7 Summary

Farm B managed to produce a higher annual milk production than Farm A with a smaller number of cows. Thus, this suggests that the use of a PMR and using ryegrass as forage led to better milk productivity. This study showed that cows being fed ryegrass as forage, produced a greater quantity of milk compared to those fed on maize silage. On the other hand, on Farm A, maize silage may have led to increased milk yields. An increase of 11.96% in milk production was observed on Farm A when comparing July 2023 with July 2024 after 12 months of feeding with maize silage included in the TMR. Despite the milk production of Farm B remaining higher than that of Farm A, no statistically significant change was seen between July 2023 and July 2024 yields.

The higher milk production of Farm B can be attributed to the utilisation of a PMR system together with a milking robot, and a better ventilation system. This therefore gives rise to further studies.

Regarding milk compounds, literature is still at a crossroads on whether maize silage is superior to other forages and has a positive impact on milk yield. In order to further analyse the effect a feeding ration has on milk quality, I recommend that individual dairy farms in Malta analyse milk compounds on a regular basis.

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