Norwegian University of Life Sciences

Milk yield and quality in relation to the kid rearing strategies

By

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This thesis is submitted as a partial fulfillment of a master degree in feed manufacturing technology at the Department of Animal and Aquacultural Science, Norwegian University of Life Science. Aas, Norway.

ABSTRACT

The aim of this study was to evaluate the effect of kid rearing strategies on the milk yield and quality. Sixty two lactating does were assigned into three kid rearing strategies. In the first strategy kids were separated from their mothers two days after kidding and raised artificially by milk replacer (n=20), Strategy two does stayed with the kid during the day and separated at night/partly suckling (n=23) and in the last strategy kids were allowed to suckle for the whole day until weaning(n=19). Does were milked twice per day and milk registration was done on Tuesdays and Wednesdays from week 5 to week 26 except week 10. Milk samples were registered by mixing the morning and evening milk and analyzed for fat, protein, lactose and somatic cell count. Weights of the does were measured at two days, five weeks and twelve weeks after kidding. Eighty four kids of both sexes were grouped according to the rearing strategies as described earlier. Weight of the kids were measured at birth, five weeks, seven weeks, ten weeks and fifteen weeks after kidding, these weights were used to calculate the daily weight gain. Milk protein, lactose and somatic cell count were affected ($P<0.05$) by the week of the year while milk yield and milk fat were affected ($P<0.05$) by the kid rearing strategy, age of the goat and week of the year. Birth type did not show any significant effect on the milk yield and milk fat. Mean daily yield during the first 5 weeks of lactation was higher ($P<0.001$) in the goats under strategy one (1.21±0.08litres) compared to strategy two (0.80±0.08litres) and three (0.39±0.09litres) while the milk fat was higher in the goats under strategy three (4.71±0.23%) and less in goats under strategy two (3.46±0.21%) and one (4.52±0.19%). Post kidding weights of the goats were only affected by age of the goat ($P<0.001$). Daily weight gain of the kids was affected ($P<0.001$) by rearing strategy and age of the kids. Kids reared artificially in strategy one gained more weight (0.18±0.01kg/day) the same as the kids under strategy two (0.18±0.01kg/day) compared to kids in strategy three (0.12±0.01kg/day). Artificial rearing seems to be practical if the cost of labor and the price of milk replacer are low compared to the price of milk.

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DEDICATION

I would like to dedicate this thesis to my parents (Appelesy Isaya Ketto and Damaris Ketto), my siblings (Ruth and Thadeus) and my fiancée (Miss Antonia), for their devotions and encouragements which gave me strength always.

DECLARATION

I hereby declare that this thesis is my own work and is submitted as a partial fulfillment for Master of Science in Feed Manufacturing Technology and delivered to Norwegian University of Life Science. This thesis has not been submitted to any other learning institution.

Signature_____

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ACRONYMS

UMB	Norwegian University of Life Sciences
IHA	Department of Animal and Aquacultural Sciences
SUA	Sokoine University of Agriculture
DASP	Department of Animal Science and Production
SCC	Somatic cell count
kg	Kilogram
ml	Milliliter
l	Liters
FAO-STAT	Food and Agriculture Organization-Statistics
SHF	Centre for Animal Production Research (Small ruminant unit)
USD	United Stated Dollar

LIST OF STATISTICAL NOTATIONS

*	Significance level at P<0.05
**	Significance at P<0.01
***	Significance at P<0.001
Den	Denominator
DF	Degree of freedom
GLM	General linear model
LSMEANS	Least square means
n	Number of observations
NS	Non significance (P>0.05)
Num	Numerator
P	Probability level
SAS	Statistical Analysis System
SE	Standard error

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background information

In the global perspective goats are kept for meat, milk, and fiber. Meat and milk are the primary products from many goat production systems. Goat meat is the primary product in most of developing countries compared to milk; this is because in these regions goats are bred for weight gain instead of milk production. In developing countries milk production from goats is very low and if utilized is consumed at household level, where it serves as an important source of protein(Haenlein, 2004), while in developed countries milk goat is converted into important dairy products mainly cheese and commercially sold (Solaiman, 2010).

In Norway goats are mainly bred for milk production with high management costs during winter and less costs in summer. This is because goats are kept in insulated barns during winter from October to May or June when they are taken to the mountains for pasture grazing up to September. Goats are bred in August to November and give kids in the spring (February or March) where they are fed indoor with roughages mainly silage with concentrate supplementation in the entire period of the peak lactation until May/June when they are taken to the pasture (Eik, 1991; Eik *et al*., 1991).

Goat milk is very important in processing dairy products in Norway i.e. Brown whey cheese which is regarded as traditional dairy product from dairy goats (Chigwa, 2011; Eknæs & Skeie, 2006). The production of Brown whey cheese has declined. This contributed to the development of new type of cheese from goat milk “Snøfrisk” (i.e. snow fresh) a white spreadable cheese with high demand within the country and abroad. Snøfrisk has short shelf life compared to the brown cheese (Asheim and Eik, 1999). It is important to have an even distribution of the milk of good quality to the dairies to have this product available in the market throughout the year. This may be achieved by improvement in feeding and other management practices e.g. kid rearing or adjustment of kidding season to April or early of May

rather than February so as to have more milk when the prices are higher in November, December and January, this may lead to improvement of income to farmer through even distribution of milk to the quota and selling of the kids at the time when is easier to sale kid meat in August just before lambs are slaughtered (Asheim & Eik, 1999).

Kids can be reared artificially by milk replacer, by partly suckling during few hours during the day and natural rearing by suckling until weaning (Havrevoll *et al*., 1991). Young born animals need colostrum and liquid feed (milk) in their early lives for their survival; this is because colostrum serves as an important source of minerals, fat as energy source, vitamins and antibodies for protection against infections while at their early lives they are unable to digest solid feed because they have chymosin and pepsin as enzymes responsible for digestion of milk in abomasum (Gall, 1981; Morand-Fehr, 1987; Sheldrake and Husband, 1985).

Choice of the kid rearing strategy can be influenced by several factors e.g. the price of milk, price of kid weight and the cost of labor (Gall, 1990). Attention in the goat sector in Norway is based on the price of milk which is determined by the quality of the raw milk and even distribution of milk to the dairy plants through the quota system.

1.3 Problem statement and justification of the study

Quality of the raw milk in terms of composition and somatic cell count affects both technological quality and the quality of intended product. Some of dairy products example most of cheeses types are highly dependent on the milk fat, true protein content and level of somatic cell count. Cheese yield as the indicator of benefit in cheese making is influenced by several factors including composition of the milk i.e. milk fat and total protein and the levels of somatic cell count. High correlation was observed in hard cheese between milk fat and protein content on cheese yield for Alpine goat breed (0.79 *vs*. 0.74) (Fekadu *et al*., 2005).

High levels of somatic cell count in the milk increase proteolysis process this leads to an increase in soluble whey fraction and lowers casein content, this in turn reduces the cheese yield and lowers the sensory and texture score for the ultimate product(Chen *et al*., 2010; Raynal-Ljutovac *et al*., 2007).

According to the above effect of quality of milk on the technological processes and quality of the final product, it very important to have the feasible production systems and breeding programs to improve milk yield and quality at the lowest possible cost. For this reason the current study was intended to evaluate the effect of kid rearing strategies on milk yield and quality.

1.3 Objectives

The main objective of this study was to evaluate the effect of the kid rearing strategies on the milk yield and quality and the specific objectives were as follows:

- To evaluate the effects of kid rearing strategies on weight gain by the kids and the weight of the doe after kidding and
- To evaluate the effect of week of the year, age of the goat, and birth type on the milk yield and quality.

1.4 Hypothesis testing

Ho: Milk yield and quality is not influenced by the kid rearing strategies.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Milk yield

Milk yield by the doe is determined by several factors including genetical composition, feeding regime, stage of lactation, production system and suckling/milking frequency(Goetsch *et al*., 2011). Study conducted on Murciano-granadina goat breed by Peris *et al*., (1997) showed that milk yield reached peak at week 4 and 5 in both does under natural and the artificial rearing groups, where the milk yield was 2.0±0.1kg and 1.93±0.06kg for the natural reared group and artificial reared group respectively. Goats managed in natural rearing produce more milk throughout the lactation compared to the goats under artificial rearing (Table 1), however the amount of marketable milk was higher in artificial rearing strategy compared to the natural rearing strategy(Delgado-Pertíñez *et al*., 2009a).

Table 1: Mean values (±SE) of milk yield depending on the rearing strategies (natural rearing, NS or artificial rearing, AR) and prolificacy (single birth, SB or twin birth, DB) in Payoya breed

Item	Rearing systems (RS)		Prolificacy (PR)		*P*		
	NS ± SE	AR ± SE	SB ± SE	DB ± SE	RS	PR	RS × PR
No. of goats	35	35	24	46			
Weeks 1–5							
Daily milk yield	3.80 ± 0.09	2.65 ± 0.08	2.58 ± 0.10	3.53 ± 0.08	***	***	NS
Total yield	140.2 ± 5.7	95.4 ± 6.2	96.3 ± 7.3	129.7 ± 5.9	***	***	NS
Daily marketable milk	1.96 ± 0.07	2.65 ± 0.08	2.00 ± 0.09	2.54 ± 0.07	**	*	NS
Total marketable milk	74.5 ± 4.2	95.4 ± 6.2	72.9 ± 6.1	91.7 ± 4.8	*	*	NS
Weeks 6–30							
Daily milk yield	2.10 ± 0.06	1.74 ± 0.08	1.72 ± 0.07	2.03 ± 0.06	NS	NS	NS
Total yield	367.4 ± 27.2	304.6 ± 35.8	300.7 ± 37.1	355.6 ± 28.4	†	NS	NS
Total lactation (210 days)							
Daily milk yield	2.42 ± 0.06	1.90 ± 0.06	1.89 ± 0.06	2.31 ± 0.06	*	*	NS
Total yield	507.6 ± 29.7	400.0 ± 40.4	397.1 ± 41.8	485.3 ± 32.0	*	†	NS

NS: not significant, $P > 0.10$.
† $P \leq 0.10$.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Source: Delgado-Pertíñez et al. (2009a)

Study on Norwegian dairy goats during lowland grazing in May and June by Eik (1996) showed higher milk yield in the does without suckling kids (1.56liters/day) compared to the does with one (1.42liters/day) and two (1.02liters/day) suckling kids

Study by Eik (1990) showed the effect of levels of concentrates on the milk yield and quality of Norwegian dairy goats in early lactation between multiparous does and primiparous does at higher levels of concentrate supplementation milk yield, protein and fat was higher in multiparous does compared to the primiparous goat i.e. (2.62±0.07 *vs.*1.91±0.06liters/day), (2.95±0.03 *vs.*2.94±0.04%) and (4.07±0.09 *vs.*3.78±0.11%) respectively while at lower levels of concentrate supplementation only protein and milk fat were higher in the primiparous does compared to the multiparous doe i.e. (4.10±0.11 *vs.*3.72±0.09%) and (2.97±0.04 vs.2.85±0.03%) respectively. Milk yield in lactation by pure bred Maltese goats increases as the age or parity of the doe increases from the first parity (257±5.65liters) to the third parity (301±4.38liters), on the other hand does kidding singles produce less milk (280.5±3.22liters) compared to the does kidding twins (288±5.65liters)(Carnicella *et al*., 2008). Number of kids born and age of the goats both influences the milk yield by the doe especially in the early lactation(Mourad, 1992). Study by Browning Jr *et al*. (1995) revealed that the alpine does in kidded singles produced low amount of milk in lactation (775±36liters) compared to the does kidded twins (834±32liters) and triplets (903±45liters).

2.2 Milk quality

Results on milk quality based on kid rearing strategies as reported by Delgado-Pertíñez *et al*. (2009a) showed that milk fat, protein, lactose and somatic cell count were higher under artificial reared goats compared to the naturally reared goats i.e. fat (5.09±0.06% *vs.* 4.69±0.06%), protein (3.71±0.03% *vs.*3.60±0.02%) and lactose (4.72±0.02% *vs.*4.71±0.02%) and somatic cell count (1638±78 vs.1446±63%). Study by Eik *et al* (1996) showed high milk fat from the Norwegian goat breed without suckling kids (3.61%) in the mountain grazing period compared to the does with one suckling kid(2.69%) and two suckling kids(2.53%).

Does kidded singles produce higher milk fat, protein and lactose compared to those with multiple births in the early lactation (Carnicella *et al*., 2008; Delgado-Pertíñez *et al*., 2009a).

Milk Lactose protein and fat in the milk was the same for the goats kidded singles and those kidded twins (Carnicella *et al*., 2008).

Higher values for the milk components (fat, protein and total solids) were recorded at the beginning and the end of lactation while lowest value was at the mid lactation. Fluctuation of milk fat was higher compared to milk protein and total solids(Mestawet *et al*., 2012).

Milk somatic cell count as milk fat and protein changes with lactation stage and parity or age of the goats. Higher values for somatic cell count were observed at the end of lactation and at the fourth parity (Gomes *et al*., 2006; Paape *et al*., 2007).

2.3 Post kidding weight of the does

Since the variation in goat milk production (20-30%) is explained by body weight variation, body weight of the goat is very important parameter in the milk yield in the current lactation and the next lactation. The effect of body weight of the goat on milk production become positive if the abdominal volume and udder volume are taken in to consideration (Gall, 1980). Milk produced by the goat is determined by the weight of the goat after kidding on the next lactation. During suckling period goats, lose about 4.8±6.8kg and gains 3.4±6.5kg during the dry period ready for the next breeding season(Constantinou, 1989).

Study by Eik *et al*.(1996) revealed that the average live weights of the doe during mountain grazing period was reduced with 3.2 and 2.5kg for the does with zero and those with suckling kids respectively.

2.4 Kid weight gain

Weight gains of kids are the function of several factors like genotype, sex of the kid, age of the kid management factors e.g. feeding and housing. Study by Delgado-Pertíñez *et al*., (2009a) showed that kids under different strategies possess different weight gains at different ages e.g. at seven days after kidding, kids under natural rearing gained less weight per compared to the artificial reared kids (113±7 *vs*. 127±5 grams per day) while from 7 to 14 days after kidding kids under natural rearing gained more weights per day compared to the kids under artificial rearing (151±7 *vs*.117±6 grams). The study based on meat goats by Paez Lama *et al*. (2012)

showed that natural rearing strategy of Criollo kids in Argentina was more economical justified compared to the artificial rearing and this was the attribute of high costs associated with milk replacer and labor which were not compensated by the price of kid weight.

Eik *et al.* (1996) showed higher weight gain in the suckling kids of Norwegian breed compared to the non-suckling kids of the same breed (160-180 *vs.* 50-70gram/day). The Average daily gain in Colmenarena and Rubia del molar sheep breed lambs in Spain as reported by de la Fuente *et al*. (1997) showed the higher gain by lambs reared artificially and less gain from the suckling lambs in 15-30 days after lambing in all breeds i.e. Colmenarena (0.31 vs. 0.24 kg/day) and Rubia del molar (0.31 vs. 0.25kg/day).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of the study

The study was undertaken at the Resource Centre for Goats at Senja Videregående Skole, Northern of Norway.

3.2 Animals and their management

Sixty two (62) lactating does Norwegian dairy breed were grouped into three different groups based on the kid rearing strategies. The first strategy was the artificial rearing group where the kids were separated of from their mothers two days after kidding (n=20). In the second strategy kids were allowed to stay with their mothers for some hours during the day and separated at night (23). The third strategy does were suckled by their kids until five weeks which was the weaning age (19). Goats were fed silage and 0.5 kg of concentrate before kidding and increased by 0.1kg to 0.9kg/day in the days after kidding.

84 Kids of all sexes from each goat were grouped according to the treatments, strategy one (Artificial rearing, n=41), strategy 2 (Partly suckling, n=21) and strategy 3 (Natural rearing n=22). Strategy one kids were colostrum fed for two days after kidding, then fed milk replacer afterwards while kids in strategy two were allowed to suckle for some hours during the day and the kids in strategy three were reared naturally by suckling without restriction until weaning (Five weeks).

3.3 Milk recording and samples analysis

Goats in each kid rearing strategy were milked twice per day on Tuesday and Thursday of each week from week 5 to week 26. Average daily yields were calculated to have daily milk yields.

Milk samples were collected once per week from morning and evening milk and analyzed for the milk fat protein lactose and somatic cell count by using Fossomatic method.

3.4 Measurements of post-kidding weights of the doe

The doe weights were recorded at three different stages, at two days after kidding, five weeks and twelve week after kidding.

3.5 Kids weight gain

Kid weights were recorded at birth, five, seven, ten and fifteen weeks after kidding. These weights were used to calculate weight gain as the ratio of differences between two weights recorded at two successive weeks to the time interval in days within the weeks and was expressed as kilogram per day. Expressed as;

$$\text{Weight gain (kg/days)} = (W_2 - W_1)/\text{days};$$

Where W_2 and W_1 are the final and initial weight of the kid respectively.

Age of the kids was expressed as day of gain which was the average of successive days within the gain. Expressed as;

$$\text{Age of the kid (days)} = (D_1 + D_2)/2$$

Where D_1 and D_2 are days of gain.

3.6 Statistical analyses

Data set for milk yield and quality was analyzed in two parts, as full data set for entire experimental period (week 5 to 26) and in the second analysis; data set was partitioned into two i.e. period before weaning and period after weaning. Mixed procedure of SAS (SAS, 2008) was used in all cases to analyze the effect of kid rearing strategies, week of the year, age of the

doe, birth type, effect of repeated measurement of the doe and the interaction between Kid rearing strategy and week of the year on the milk yield, milk fat, protein, lactose and somatic cell count (SCC). The following model was used:

Milk yield/Quality = Mean + Kid rearing strategy + Age of the doe + Week + Birth type + effect of the doe + Kid rearing strategy×Week + Residual

Milk yield and quality (protein, fat, lactose and somatic cell count) were treated as dependent variables.

Independent variables were classified as follows: Kid rearing strategies (1 = Control group/non-suckling group, 2=half day suckling strategy and 3= full day suckling until week five), age of the doe (1 = 1year, 2= 2years and 3 = 3years), birth types (1 = singles, 2= twins and 3=triplets), week of the year (5, 6. 7. 8, 9, 11, 12, 13, 14, 15, 17, 19, 21, 23 and 26), effect of the goat (62 does repeated in the kid rearing strategies, week of the year, and age of the goats), interaction between kid rearing strategy and week of the year and residual or error term for the repeated measurements within the goats and other non-explained effects.

General linear model procedure of SAS (SAS, 2008) was used to analyze the effect of kid rearing strategies, birth type and age of the goat on the weights of the goat recorded at two days, five weeks and twelve weeks after kidding. The following model was used:

Weight = Mean + Kid rearing strategy + Age of the doe + Birth type+ Residual

Weights of the goats at two days, five weeks and twelve weeks after kidding were classified as dependent variables. Independent variables used in this model were the same as for the previous model on milk yield and quality except effect of the goat and kid rearing strategies×week of the year were excluded.

The effect of kid rearing strategies, sex of the kid, birth type, effect of the goat, age of the kid and interaction between kid rearing strategy and age of the kid on the weight gain by the kids were analyzed by mixed procedure of SAS (SAS, 2008), where effect of the goat was treated as the random effect. The following statistical model was used:

Weight gain = Mean + Kid rearing strategy + Sex of the kid + Age of the kid + Birth type + Effect of the goat + Kid rearing strategy×Age of the kid + Residual.

Weight gain by the kid was treated as the dependent variable. Classification of independent effects for this model was as follows; kid rearing strategies (1= Control group non-suckling, 2=half day suckling, 3= full day suckling strategy), sex of the kid (1=male kids and 2=female kids), Age of the kid (1=17.5, 2=42, 3 =59.5, and 4=87.5 days), birth type (1=Singles, 2=twins and 3=triplets). Effect of the goat was treated as random variable, where 62 does were used, the interaction between kid rearing strategy and week of the year and the error term for the repeated measurement within the goat and other non-explained effects.

CHAPTER FOUR

4.0 RESULTS

4.1 Milk yield

Milk yield and composition from each kid rearing strategy in pre-weaning and post-weaning period are presented in Table 2. Milk yield was significant affected ($P<0.001$) by the kid rearing strategies in the pre weaning period. Appendix 10 shows the effect of treatments on the milk yield during entire experimental period were the goats under artificial rearing in strategy one they produce more milk (1.20±0.05l) compared to the goats under strategy two half day suckling (1.09±0.05l) and the goats in strategy three where kids were reared naturally (0.91±0.05l) . Large variation in milk yield was experienced in first five weeks ($P<0.05$) (Figure 1), where milk produced by goats in strategy one was much higher (1.21±0.08l) compared to group two (0.80±0.08l) and three (0.39±0.09l).From week 11 on-wards the variation in milk production was less significant in all groups ($P>0.05$). Milk production during this period was 1.17±0.06l for strategy one, 1.23±0.06l for strategy two and 1.14±0.07l for the goats under the strategy three.

Table 2: Least square means (±SE) for milk yield and quality in relation to the kid rearing strategies in the pre weaning and post weaning periods

	Pre-weaning period				Post-weaning period			
	Strategy 1	Strategy 2	Strategy 3		Strategy 1	Strategy 2	Strategy 3	
Number of does	n= 20	n= 23	n=19	Significance	n=20	n=23	n=19	Significance
Parameters								
Milk yield (Kg/day)	1.21±0.08[a]	0.80±0.08[b]	0.39±0.09[c]	***	1.17±0.06	1.23±0.06	1.14±0.06	NS
Protein (%)	3.00±0.11	3.18±0.13	3.10±0.13	NS	2.73±0.04	2.66±0.04	2.70±0.04	NS
Fat (%)	4.52±0.19[a]	3.46±0.21[b]	4.71±0.21[a]	***	3.68±0.09	3.54±0.09	3.68±0.09	NS
Lactose (%)	*5.15±0.08*	*5.04±0.09*	*5.12±0.10*	NS	4.75±0.05	4.76±0.05	4.73±0.06	NS
SCC (×10^3 Cells/ml)	604±163	467±181	750±193	NS	523±198	553±213	415±176	NS

*NS=Not Significance, ***P<0.001, [a,b,c]Means with the different letters in superscripts differs significantly at P<0.05*

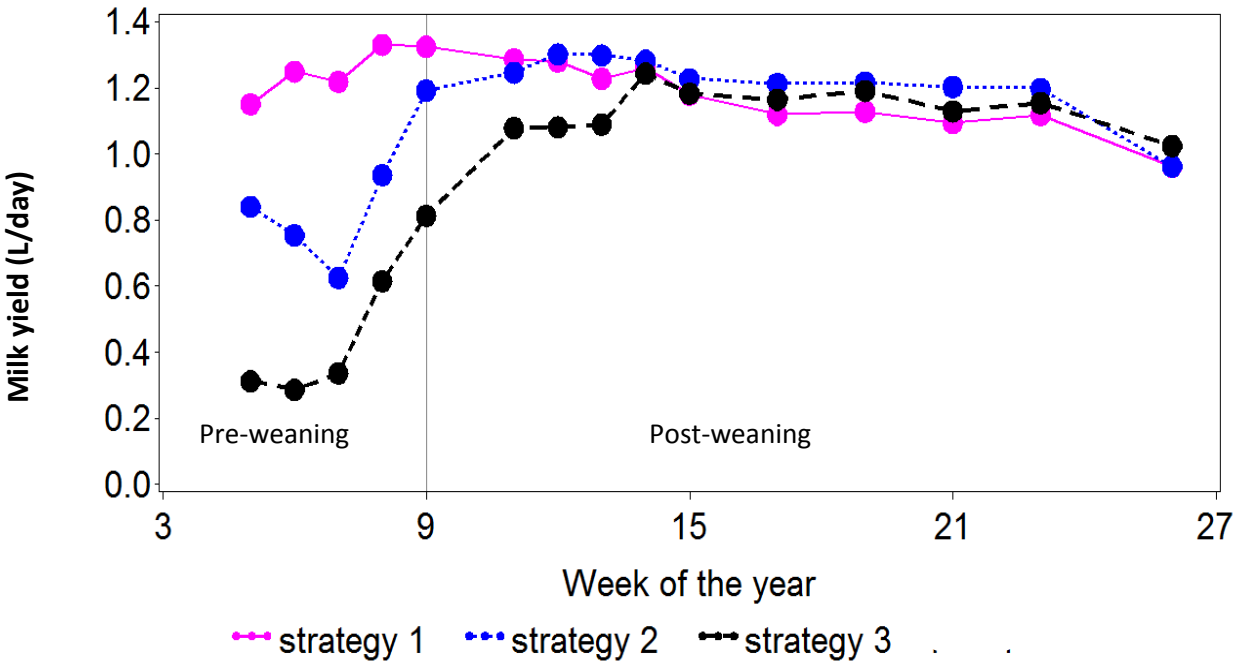

Figure 1: Trends in milk yield of the does throughout the experimental period according to the treatments

Age of the doe showed a significant effect (P<0.05) on the milk yield. Goats with three years of age produced more milk (1.16±0.06 kg/day) compared to the goats with one year old (1.01±0.04l/day) and those with two years of age (1.01±0.04l/day).

Birth type did not significantly affect (P>0.05) milk yield by the does, however does with three kids produced more milk (1.19±0.11kg/week) compared to goats kidded single (1.00±0.04kg) and the ones which kidded twins (1.00±0.04 kg).

The interaction between kid rearing strategy and week of the year is shown in Figure 1. Large variations in milk yield between the three strategies were higher in the early lactation from week 5 to week 10 (P<0.05). As the lactation preceded the variations in milk yield between the rearing strategies was reduced drastically where they coincide in week 26.

4.2 Milk quality

Pattern for milk quality in terms of its chemical composition (fat, protein and lactose) are presented in Table 1. Kid rearing strategy significantly ($P<0.05$) influenced the milk fat in the pre-weaning period while in the post-weaning period its effect was not significant. Milk fat in pre-weaning phase was higher for the goats under natural rearing in strategy three (4.71±0.09%) compared to the goats under kid rearing strategy one (4.52±0.19%) and two (3.46±0.21%). The difference in milk fat by week of the year was large in early lactation but the difference was less in strategy one and three if compared to strategy two. At week 6 the milk fat was higher for the goats in strategy three (4.92±0.18%) followed milk fat in strategy one (4.44±0.13%) and less milk fat in strategy two (2.91±0.14%). As the lactation advanced the differences in milk fat by the three strategies is reduced for example at week 13 milk fat content from the does were 3.88±0.12%, 3.87±0.12% and 3.92±0.13% for the does in kid rearing strategy one, two and three respectively (Figure 2). In all kid rearing strategies milk fat and protein decline in at the start of experiment until weaning and maintained until the later stage when it started to increase gently while the lactose content decreases through the entire experimental period.

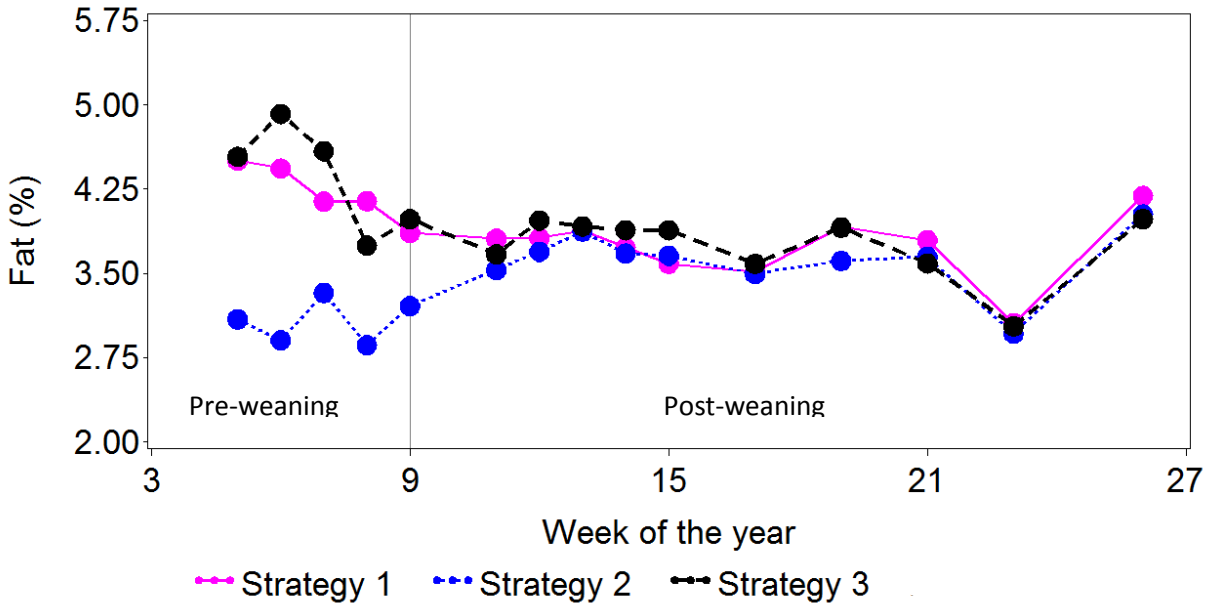

Figure 2: Variations on milk fat of the goats throughout the experimental period according to the treatments

Milk protein, lactose and somatic cell count were not significantly (P>0.05) affected by the kid rearing strategies. There was a slight difference in the levels for milk protein between the rearing strategies. Milk protein was less in strategy two (2.77±0.05%), slightly higher amount in strategy three (2.79±0.05%), followed by strategy one (2.79±0.04%) (Figure 3).

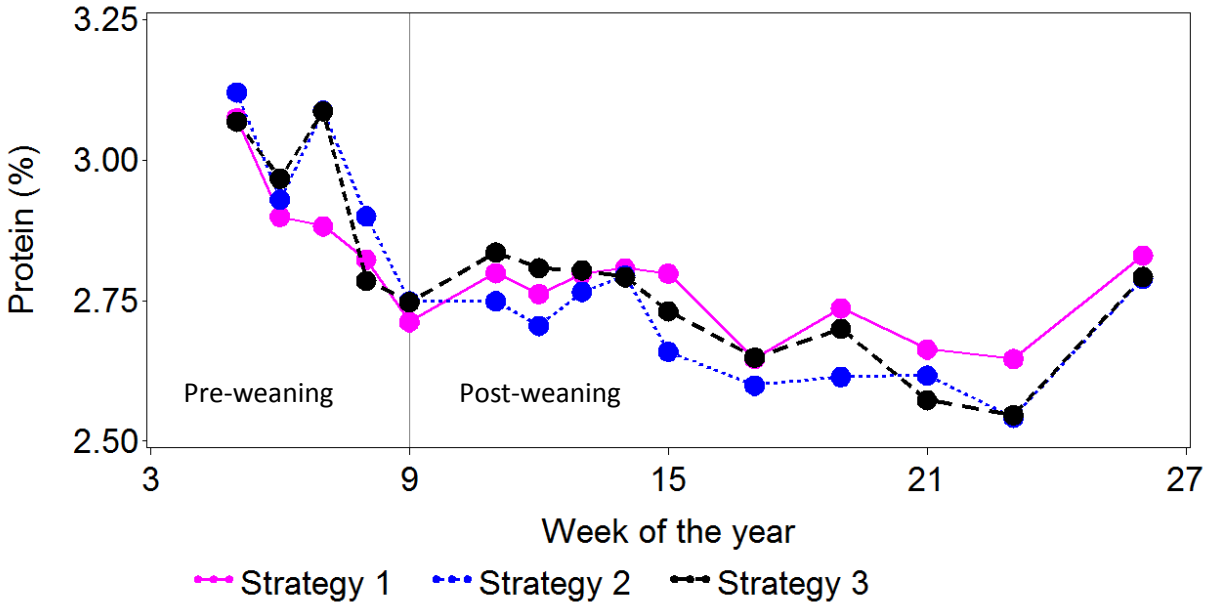

Figure 3: Variations on milk protein by the goats throughout the experimental period according to the treatments

Higher lactose content in milk was obtained in pre-weaning period compared to the post-weaning period (Table 1). In the entire data set does in kid rearing strategy two (4.85±0.05%) and three (4.85±0.05%) compared to the goats in strategy one (4.78±0.05 %). Figure 4 shows the trend of the content of lactose by the treatments.

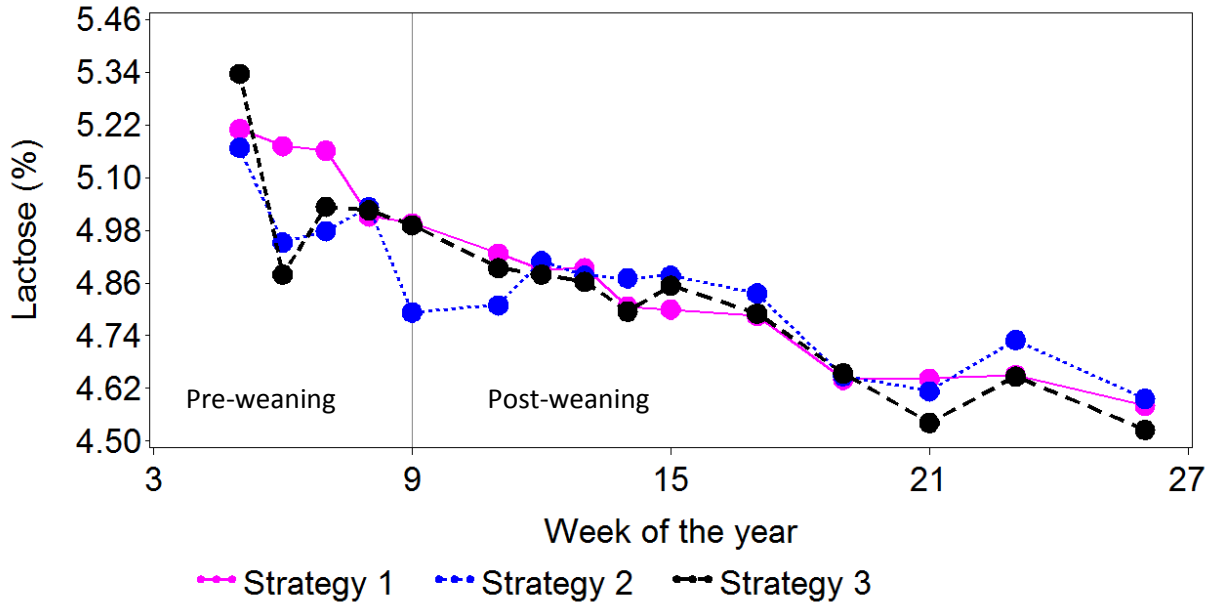

Figure 4: Variations on lactose by the goats throughout the experimental period according to the treatments

Higher somatic cell count in milk was higher (P>0.05) in kid rearing strategy three (555.62±179.81×10^3cells/ml) compared to the goats in strategy two (443.25±168.07×10^3cells/ml) and goats in strategy one (486.32±155.42×10^3cells/ml) (Figure 5).

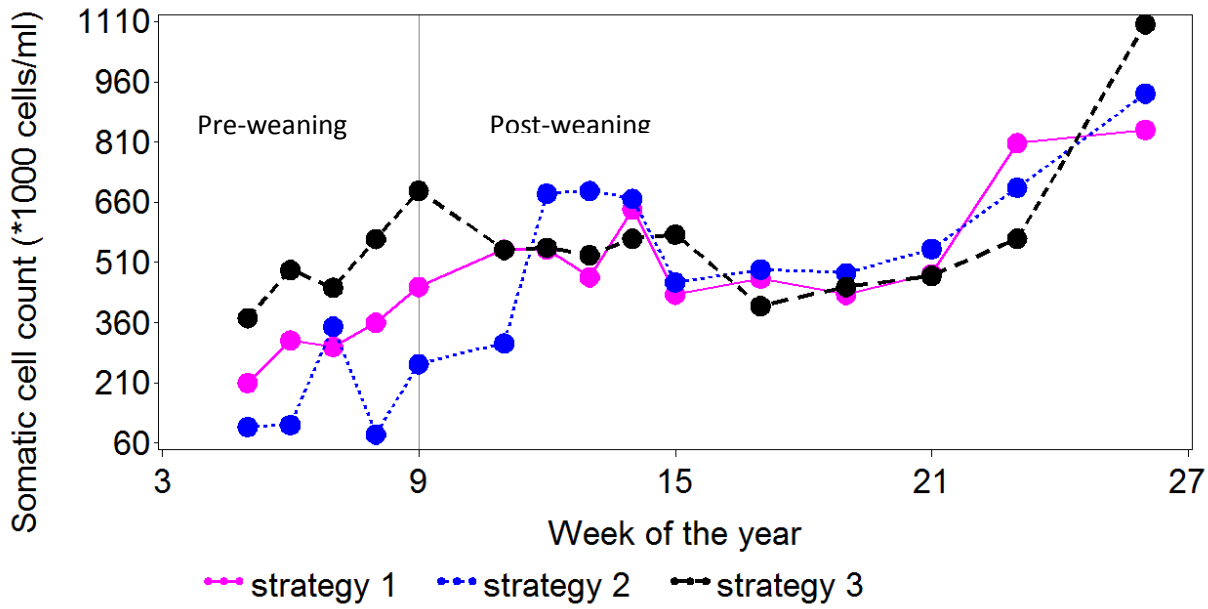

Figure 5: Variation in milk somatic cell count by the goats throughout the experimental period according to the treatments

Milk fat was only variable that was significantly (P<0.001) affected by the age of the does. Does with one year old produced higher milk fat (4.08±0.13%) compared to the does which were two years old (3.78±0.07%) and three years of age (3.68±0.07%). Milk protein was higher in does with two years old (2.86±0.04%) compared to the goats with one year old (2.76±0.07%) and three years old (2.74±0.03%). Lactose content in milk was slight higher in the does with one year of age (4.86±0.07%) compared to the does with three years of age (4.86±0.04%) and two years of age (4.85±0.05%). High levels of somatic cell count were observed in the does with one year of age compared to those with two and three years old.

Milk fat, protein lactose and somatic cell count were not significantly (P>0.05) affected by the birth type (Appendices 2.0 to 5.0). Low levels of somatic cell count were observed in does that kidded single kids compared to the does with multiple births.

4.3 Post-kidding weights of the goats

The effect of treatment on the weights of the goats at, two days (W2), five weeks (W5) and twelve (W12) weeks after kidding are shown in Appendix 7.6. The average weights of the goats were 43.39kg for W2, 47.15kg for W5 and 47.34kg for W12. Age of the goat significantly (P<0.05) affected the post kidding weights of the does. Higher weights were recorded in goats with three years of age. Other factors tested did not significantly affecting the post-kidding body weight of the goats. Goat kidded triplets were heavier at 2 days , 5 weeks and 12 weeks after kidding compared to the goats kidded singles and twins.

Goats under kid rearing strategy two suckling during the day were heavier at two days and five weeks after kidding compared to other strategies (Appendix 9.0). Goats grouped under kid rearing strategy one were heavier (45.66kg) at 12 weeks after kidding compared to other strategies i.e. strategy two(45.25kg) and three(44.02kg).

4.4 Weight gain by the kids

Effects of treatment and other factors tested for the weight gain by the kids are presented in Appendix 7. Kids under control group in strategy one showed higher weight gain at 42days (0.14±0.02kg per day) compared to the kids in strategy two kids (0.07±0.02kg per day) and those in strategy three of full day suckling (-0.01±0.02kg per day) (Appendix 8). Male kids shows higher average daily weight gain (P<0.05) compared to female kids (0.15±0.01kg *vs.* 0.14±0.01kg). Kids born as singles shows higher (P>0.05) average daily weight gain (0.16±0.01kg) compared to the kids born as twins (0.14±0.01kg per day) and triplets (0.13±0.01kg per day). Table 3 shows the mean live weights of the kids at different age in relation to the treatments. Kids under strategy three showed higher weights at in the suckling period (birth to weaning) compared to the kids in strategy one and two. In the period after weaning kids in strategy one weighed higher compared to the kids in strategy one and two.

Table 3: Mean live weights of the kid at different stages in different kid rearing strategies

	Kid rearing strategies		
	1	2	3
	n=41	n=21	n=22
Weight, kg			
Birth weight	3.12	3.05	3.20
5 weeks	9.52	8.55	10.08
7 weeks	11.52	9.64	10.80
10 weeks	15.86	13.71	15.00
15 weeks	21.38	20.25	20.69

Figure 6 shows the trend of weight gain by the kids at different age in relation to the treatments, where in the period before weaning (17.5 days) kids reared under strategy three they gained high weights compared with the kids in strategy one and two. In the period after weaning (42 days) strategy three kids lose much weight compared to the kids in strategy one and two.

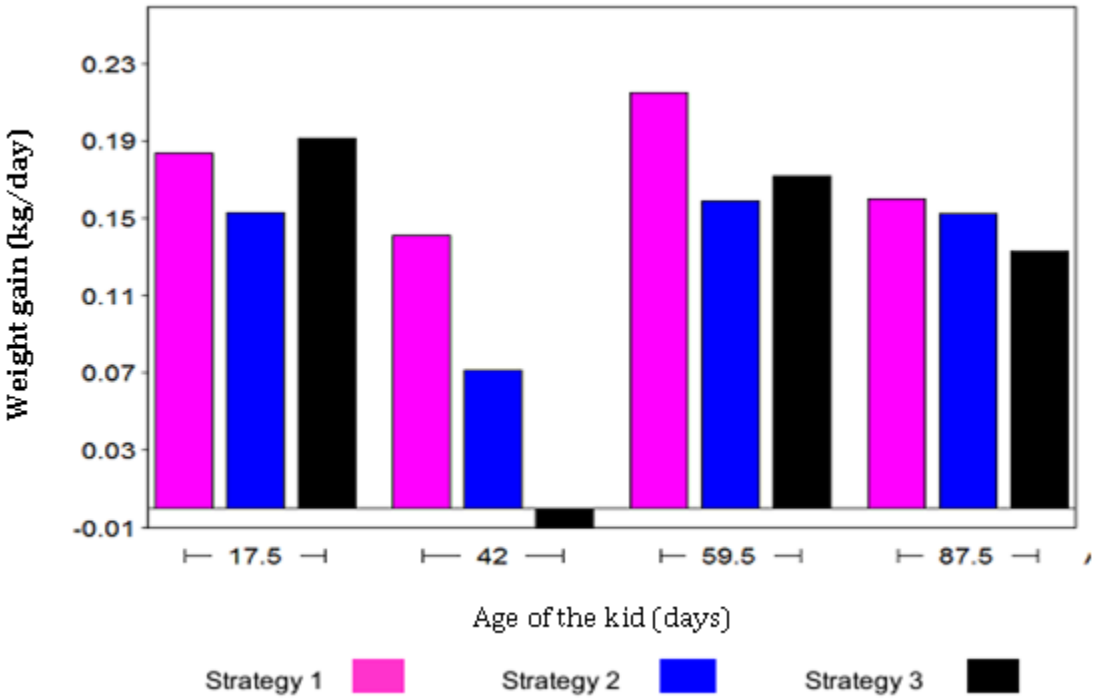

Figure 6: Weight gain by the kids at different ages in relation to the treatments

CHAPTER FIVE

5.0 DISCUSSION

5.1 Milk yield

The average milk yields by Norwegian dairy goats in the present study were similar to those obtained by Eik *et al*. (1996) who obtained the average daily yields ranging from 1.0 liter per day to 2.3 liters/day. The current study obtained significant differences in milk yield for among the kid rearing strategies. Large variation on milk yield was noticed in the first five weeks of lactation, this was similar to the study conducted by Delgado-Pertíñez *et al*. (2009a) and Peris *et al*. (1997) who obtained the similar trend with exception that the goats under artificial rearing produced less daily milk yield in both studies as compared to the natural reared goats which is different from the current study. This is because the current study did not take into account the amount of milk consumed by a kid. The current results on milk yield are in agreements with those of Eik (1996) with Norwegian dairy goats during lowland grazing where the milk yield was lower in the suckling does compared to does without suckling kids.

In the present study age significantly influenced the milk yield by the goat, as the goat gets mature, milk yield increases. This is similar with Solaiman (2010) who showed the increase in the goat milk production with age and the peak production was attained in the fourth year of age. In agreements with the study by Finley *et al*. (1984) who found that the maximum milk production from American Alpine was attained between 24 and 50 months of age. Similar to Eik (1990) obtained higher milk yield in multiparous does of Norwegian goat breed in early lactation compared to the primiparous does at different feeding intensity. The increase in the milk production with respect to the age of the goat could be due to the in the increase in body weight which is related to the increase in the udder and the volume of gastro intestinal tract which is related to the increase in the digestive capacity and the increase in the cisternal capacity as the age of the doe is increased (Goetsch *et al*., 2011).

In the current study milk production did not with increase in the number of kids born. Less milk was obtained from the does that kidded singles compared to the goats kidded multiple kids. However the studies by Crepaldi *et al*. (1999) and Goonewardene *et al*. (1999) showed

significant increases in milk production associated with the increase in the number of kids born even if does were not suckled i.e. 32 kg more for the does that kidded multiples compared to the goats kidded singles. Mourad (1992) reported the significant effect of the birth type within the two months after kidding.

5.2 Milk quality

Milk fat in pre-weaning stage was significantly affected by kid rearing strategy, week and age of the goat, while in the post-weaning phase the kid rearing strategy did not significantly ($P>0.05$) affect the milk fat. The highest value for milk fat in the pre-weaning phase was noticed in the strategy three under natural rearing compared to other strategies. This is contrast to the study by Delgado-Pertíñez *et al*. (2009a) who obtained higher milk fat in the goats under artificial rearing strategy of the Payoya autochthonous dairy goat breed in Spain. Milk protein, lactose and somatic cell count were not affected by the treatments but were affected by the week of the year. The fluctuation of milk fat with the stage of lactation was very high compared to other milk components. A similar trend was noticed by Mestawet *et al*. (2012) who observed higher variation in milk fat throughout the lactation in within four breeds studied i.e. Boer, Somali, Arsi-Bale and the crosses between Toggenburg and Arsi-Bale in Ethiopia.

Results from the current study indicated the decline in milk fat and protein from the start of experiment until weaning and start to increase at the later stage of the experiment while the lactose content was decreasing as the lactation proceeds. These results were similar with the results by Prasad *et al*. (2005) who reported the similar trend.

The current study showed the significant effect of age of the does on the milk fat before and after weaning where the yearlings/uniparous does produce more milk fat in the entire lactation compared to the does with two and three years of age, these findings are consistent with the study by Eik *et al*. (1991) who showed significantly higher milk fat in Norwegian dairy goats from uniparous goats compared to the multiparous dairy goats during the barn feeding in Norway.

Birth type was only significant in the pre-weaning period, where the goats with single births produced higher milk fat compared to the goats with multiple births. These results are similar to the results by Delgado-Pertíñez *et al*. (2009a) who obtained non-significant effect of birth type on lactose, protein and cell counts except for milk fat in the suckling phase where the goats with single births produced higher fat in their milk compared to the goats with multiple births. The higher milk production by the goats with multiple kids could be due to the higher udder volume compared to the goats with single kids (Peris *et al*., 1999).

Week of the year had a significant effect on all milk constituents i.e. protein, lactose and somatic cell counts, however neither of the quality parameters mentioned was significantly affected by kid rearing strategy in the both pre-weaning and post-weaning periods.

5.3 Weights of the does after kidding

In the current study neither kid rearing strategy nor birth type had a significant influence on the weights of the goats at 2 days, 5 weeks and 12 weeks postpartum. Post-kidding weights of the does was affected by the age of the doe. Does with higher age were having higher weights compared to the younger goats. Similarly McGregor and Butler (2010) showed the significant effect of the age on the increase of the live weight of the Australian cashmere goats, where the maximum live weight was reached at five years of age. This is in agreement with (Eik e*t al*.(1991) and Majele-Sibanda *et al*.(2000) who showed the lower live weights for the primiparous does of Matebele breed in Zimbabwe which was two-third less when compared to the multiparous does.

5.4 Weight gain by the kids

The current study has shown that kids reared naturally in strategy three had higher live weights at all stages compared to other strategies although they showed little average daily weight gain compared to other strategies. Higher live weights by the kids reared naturally (suckling kids) could be due to the presence of Insulin-like growth factor (IGF) in the milk, which acts as the growth promoter for the suckling kids compared to the non-suckling kids which received milk replacer (Baumrucker & Blum, 1993).

However in the current study non-suckling kids in strategy one grew faster compared to the kids of strategy two and the kids of strategy three. These findings agree with Delgado-Pertíñez *et al*. (2009b) who revealed that the artificial reared kids of Florida dairy goats had higher average daily gain compared to the natural reared kids of the same breed. The same findings by de la Fuente *et al*. (1997) who obtained higher weight gain by the lambs reared artificially by milk replacer compared to the natural reared lambs. Negative weight gain in soon after weaning in natural reared kids at week seven could be explained by the weaning associated stresses. This study showed significant effect of age of the kid on the weight gain, neither sex of the kid nor birth type was significant on the weight gain by the kids. Different findings were showed by Opstvedt (1968) on Norwegian goat kids where similar weight gains were recorded for the suckling kids and non-suckling kids. Male kids gained more weight compared to the female kids this could be due to the effect of male hormone in the growth.

5.5 Economics of dairy goat production

Dairy goat milk production in Norway is operated under quota system. Dairy goat farmer is will be in a good position if he/she can produce for the whole quota. Economics of any dairy production is determined by lower management costs e.g. labor costs and the costs of feed and higher economic returns through sales of milk and the goat kids if the price of goat kid is favorable. Study by Asheim & Eik. (1999) showed that it is economical for dairy goat farmer to have even distribution of the milk to the quota if the kidding is adjusted to April or early of May instead of February and get more milk in November to January when the price of milk is higher (0.39USD higher per litter). Kidding in April or early of May will be economical in terms of selling of surplus goat kids for slaughter in August just before lamb season at 6.5 to 7.5 carcass weight. This is economical if farmers deliver the goat kids for slaughter on contract. The costs associated with managing high yielding goats during summer grazing can be minimized by the reduced indoor feeding of kids and milking once per day which will reduce hours needed for worker to milk goats twice per day.

A. Klouman (personal communication, November 29, 2012) stated that it takes approximately 2 to3 minutes to milk single goat. For 62 goats, milking may last for two to three hours per day while milking twice per day will cost twice. Based on the current study artificial rearing could be more expensive compared to the natural rearing under Norwegian conditions because of high cost of labor and additional the cost of milk replacer.

CHAPTER SIX

6.0 CONCLUSION

The findings from the current study shows the large differences in milk yield and quality in the pre-weaning phase compared to the post-weaning phase. Does kept in strategy three showed higher amount of milk fat compared to other strategies in the pre-weaning period while in the post-weaning period the difference was very small. Higher levels of somatic cell count in the suckling phase (pre-weaning period) was higher in the strategy three (natural rearing) compared to the other strategies. This study noted slightly differences in milk protein and lactose in response to the treatments. High weight gain was observed in the kids reared artificially by milk replacer compared to the kids reared naturally. Neither kid rearing strategy nor litter size significantly affects the weight of the doe after kidding, at 2 days after kidding does in strategy three had lower weight compared to does in other strategies while at week 5 after kidding the strategy three does overweighed does in strategy one and two, while at week 12 after kidding does in strategy one had higher weight compared to the does in strategy two and three. As stated earlier economics of dairy goat production in Norway is highly dependent on the even distribution of milk throughout the year to fulfill the quota, adjustment of breeding season to have kidding in April or May is the optimal management decision to achieve higher economic returns from milk and sales of kids for meat. Due to high cost of labor and price of milk replacer in Norway natural rearing with the adjusted kidding season, reduction of milking times will be optimum for dairy goat farmer to have extra time for other farm activities at the same time he/she can fulfill the quota.

CHAPTER SEVEN

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CHAPTER EIGHT

8.0 APPENDICES

Appendix 1: Analysis of variance for milk yield for entire experimental period

Covariance Parameter Estimates	
Cov Parm	Estimate
DOEI(Kid rearing strategy×Age×Birth type)	0.03406
Residual	0.03440

Type 3 Tests of Fixed Effects

Effect	Num[1] DF	Den[2] DF	F Value	Pr > F
Kid rearing strategy	2	67	11.65	<.0001
Week	14	708	36.36	<.0001
Age	2	67	3.75	0.0286
Birth type	2	67	1.53	0.2233
Kid rearing strategy×Week	28	708	14.98	<.0001

Appendix 2: Analysis of variance for milk fat for entire experimental period

Covariance Parameter Estimates	
Cov Parm	Estimate
DOEI(Kid rearing strategy×Age×Birth type)	0.08787
Residual	0.1517

[1] Numerator degree of freedom

[2] Denominator degree of freedom

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Kid rearing strategy	2	67	17.65	<.0001
Week	14	708	25.45	<.0001
Age	2	67	17.29	<.0001
Birth type	2	67	0.84	0.4364
Kid rearing strategy×Week	28	708	11.10	<.0001

Appendix 3: Analysis of Variance for protein for entire experimental period

Covariance Parameter Estimates	
Cov Parm	Estimate
DOEI(Kid rearing strategy×Age×Birth type)	0.02263
Residual	0.03245

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Kid rearing strategy	2	67	0.09	0.9135
Week	14	708	24.46	<.0001
Age	2	67	3.93	0.0244
Birth type	2	67	0.17	0.8467
Kid rearing strategy×Week	28	708	1.44	0.0674

Appendix 4: Analysis of variance for lactose for entire experimental period

Covariance Parameter Estimates	
Cov Parm	Estimate
DOEI(Kid rearing strategy×Age×Birth type)	0.02522
Residual	0.04624

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Kid rearing strategy	2	67	0.23	0.7940
Week	14	708	31.27	<.0001
AGE	2	67	0.03	0.9673
LTSZ	2	67	1.78	0.1773
Kid rearing strategy×Week	28	708	1.45	0.0632

Appendix 5: Analysis of variance for somatic cell count for entire experimental period

Covariance Parameter Estimates

Cov Parm	Estimate
DOEI(Kid rearing strategy×Age×Birth type)	333762
Residual	270532

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Kid rearing strategy	2	67	0.20	0.8164
Week	14	708	5.95	<.0001
Age	2	67	1.75	0.1809
Birth type	2	67	0.45	0.6400
Kid rearing strategy×Week	28	708	1.01	0.4578

Appendix 6.0: Analysis of variance for post kidding body weights of the doe

Appendix 6.1: Analysis of variance for the weight of the doe at 2 days post-kidding

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1198.59	199.77	6.59	<.0001
Error	4	1637.70	30.33		
Corr. Total	60	2836.30			

R-Square	Coeff Var	Root MSE	WT2 Mean
0.422592	11.78	5.51	46.76

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Kid rearing strategy	2	13.42	6.71	0.22	0.8023
Age	2	1145.45	572.	18.88	<.0001
Birth type	2	15.10	7.95	0.26	0.7704

Appendix 6.2: Analysis of variance for weight of the doe at 5 weeks post-kidding

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1197.41	199.57	7.71	<.0001
Error	55	1424.39	25.89		
Corr.Total	61	2621.79			

R-Square	Coeff Var	Root MSE	WT5 Mean
0.46	10.79	5.09	47.15

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	31.81	15.90	0.61	0.54
Age	2	1128.05	564.02	21.78	<.0001
Birth type	2	34.13	17.06	0.66	0.52

Appendix 6.3: Analysis of variance for the weight of the doe at 12 weeks post-kidding

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1061.32	176.89	7.68	<.0001
Error	55	1266.57	23.03		
Corr.Total	61	2327.89			

R-Square	Coeff Var	Root MSE	WT12 Mean
0.46	10.14	4.79	47.34

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Kid rearing strategy	2	26.89	13.45	0.58	0.5611
Age	2	967.23	483.61	21.00	<.0001
Birth type	2	28.09	14.05	0.61	0.5471

Appendix 7: Analysis of variance for weight gain by the kids

Covariance Parameter Estimates

Covariance of parameters	Estimate
DOE ID	0.000187
Residual	0.008957

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Kid rearing strategy	2	230	7.05	0.0011
Age of the kid	3	230	24.03	<.0001
Sex	1	230	1.26	0.2626
Birth type	2	59	2.12	0.1293
Strategy×Age	6	230	4.30	0.0004

Appendix 8: Least square mean (±SE) for the kids in relation to the treatments

	Kid rearing strategies			
	1	2	3	Significance
Number of kids	n=41	n=21	n=22	
Weight gain (kg/day)				
17.5 days	0.18±0.02	0.15±0.02	0.19±0.02	NS
42.0 days	0.14±0.02[a]	0.07±0.02[b]	-0.01±0.02[c]	***
59.5 days	0.22±0.02[a]	0.16±0.02[b]	0.17±0.02[ab]	***
87.5 days	0.16±0.02	0.15±0.03	0.13±0.02	NS

*NS = Not significant, ***P<0.001, [a,b,c] Means in the same rows followed by different letters in superscripts differs significantly at P<0.05*

Appendix 9: Means for weights of the does by the treatments

	Kid rearing strategies		
	1	2	3
Number of does per treatment	n=20	n=23	n=19
Weights, Kg			
2 days	44.40	44.80	44.64
5 weeks	44.0	45.82	44.64
12 weeks	45.66	45.24	44.02

Appendix 10: Effect of treatments on the milk yield in the entire experimental period

	Kid rearing strategies			Significance
	1	2	3	
Number of does	n=20	n=23	n=19	
Milk yield, Liters/day	1.20±0.05[a]	1.09±0.05[b]	0.91±0.05[c]	***

****P<0.001*, [a,b,c] *Means with the different letters in superscripts differs significantly at P<0.05*