Comparing suckling and artificial milk systems for rearing organic beef cattle

Case study at Droevendaal farm

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ABSTRACT

"*Stierkalf waarding*" is a project carried out in Droevendaal farm (Wageningen University, NL). The aim of this project is search for animal friendly solutions for rearing calves organically, because on many organic dairy farms bull calves are sold to conventional farms and raised in a conventional way. The project started rearing the calves with organic artificial milk, but it resulted an expensive solution.

Increased interest in suckling systems raised the idea of using them to rear the calves. Compared to artificial calf rearing, suckling systems are more beneficial to the welfare of calves. The calf is nursed by the mother or a suckler cow, learn to eat roughage at a younger age, have social contact with other calves and cows and have space enough to exercise and play. Most of these factors are absent in artificial calf rearing systems. One of the superior goals in organic farming is to provide all animals with optimal conditions and opportunities to express their natural behaviour, and to meet their natural needs. Consequently suckler systems, where the calves are kept with a cow seem a relevant solution.

The objective of this thesis was to compare the artificial calf rearing system with a suckling system, given that it seemed to fit more in the organic philosophy and it might result a cheaper option. An experiment was carried out between December 2004 and May 2005 to compare the two systems. Eighteen calves and two cows were assigned to the two treatments. All animals were a crossbred between Holstein-Friesian and an old Dutch bred (MRY – "*Maas-Rijn-Yssel vee*"-). Six groups of calves (n=3) were made taking into account age, bred and live weight, getting six comparable groups. The control groups were fed with artificial milk, and the others, the experimental groups, stayed with a nurse cow (one cow reared two groups).

Productive and economic parameters were analysed. Calves and cows were weighed every Wednesday morning during the experiment. Because calves cannot be considered independent (specially in the suckling group) the group of three calves was considered the experimental unit. Theoretical growth rates were calculated with the average weight of calves of a group, fitting the curves to an exponential function ($r^2 >$ 0,99). Behavioural aspects were not specifically included in the experiment, but records about abnormal behaviours and health problems were kept daily. Economic analysis was made taking into account direct costs and estimations of the farm managers.

Differences between the two systems were found, but they were not significant (P = 0,141). Contrary to the expected better growth for the suckling group, bucket-fed calves grew faster till weaning. The main reasons for this is that cows were low-productive ones and they "stole" solid feed from the calves. It was a limitation of the experiment to separate solid feed from the cow and from the calves, so in the suckling group cow was taking a great part of the cereals and concentrates for the calves while in the bucket-fed group they were eating almost *ad libitum.* According to the literature a more variation in the growth of calves in the suckling group was found, because getting the milk created hierarchies between the calves from a group. Finally available data about post-weaning growth of two groups showed that suckling group compensate their slower growth, getting higher live weight at 180 days.

No behavioural abnormality was found in the two groups. Calves and cow adapted to the suckling system from the first day. Only one health problem was reported in one calf in a bucket-fed group. It was an infection in the umbilical cord, probably due to a problem of cross-suckling (when calves suck to each other, because of the behavioural deprivation of suckling). This calf finally died, and even it couldn't be directly attributed to this infection, it may be a possibility.

Suckling option resulted to be cheaper in the three comparisons. First two groups were 91 days in the experiment and costs to raise a calf were € 224 for the bucket-fed calves and € 131,2 and € 198,2 for the suckling groups. In the third trial (70 days) costs were € 103 and € 170 for the suckling and the bucket fed calves, respectively. Costs for the suckling group are much more variable than for the bucket fed one. They depend basically on the costs for acquiring and maintaining the suckling cow. It is important to take into account that in our experiment, culling cows were used, so the price of them was cheap (€ 500 and € 800) and they can be sold after the suckling period as meat for similar prices than were bought, because the live weight did not change. In our case transportation costs were relatively cheap (around € 80 per cow) and there were no vet costs, but there is still a quite important margin between the two options that make the suckling option more economical.

We concluded that suckling with culling cows is a good option to rear calves that come from dairy farms and can be cheaper than the artificial rearing, in conditions of organic production. Growth was not the expected, but solving some limitations about the solid feed intake an ensuring that cow produces enough milk for all the calves, calves can grow perfectly. Further research has to be done, because only one case was analysed with a few animals. Also availability, profitability and management of the culling cows for a suckling use have to be studied.

CONTENTS

1. INTRODUCTION

1.1 SUSTAINABLE PRODUCTION

Safe food, healthy animals, biodiversity and sustainable nature are at the top of the social agenda. Food is a basic need, but that food needs to be safe, healthy and varied. The animals we keep for meat, milk, cheese, eggs and for companionship must be healthy and kept under conditions in which they behave normally.

So, ideally animals should be kept in husbandry systems which allow them to express their natural behaviour. However, in almost all production systems, animals have to adapt themselves to the husbandry system (Langhout, 2003). According to the Dutch (http://www9.minlnv.nl) and European (http://europa.eu.int/comm/food/animal/welfare/references_en.htm) policy on welfare, animal production systems have to be developed towards the needs of animals.

European agriculture has, over the past decades, been dominated by high input and high output systems. Scientific and public concerns over intensive agricultural practices have, however, increased in the recent years. For this there has been an unprecedented increase in organic farming in Europe during the last decade, and in some countries, this has also been reflected in a growing number of livestock managed organically (Roderick *et al*. 1996).

The philosophy of organic farming emphasises the need to produce food in an "integrated humane, environmentally and economically sustainable agricultural production system" (Lampkin and Measures, 1995 in Roderick *et al*. 1996). Looking at the different regulations and aims of organic animal production we can identify the following key principles (UKROFS, 1993, in Roderick *et al*. 1996):

- The husbandry systems must conform to the highest welfare standards
- The animals must be fed with feeds that suit their physiology
- The feed is mainly produced on the farm
- Animal health should be maintained through sound preventive husbandry, animal welfare and appropriate housing and feeding systems

These principles require substantial changes to conventional, intensive animal husbandry systems.

Suckling in mammals is an interesting as well as extremely important area of research. Interesting, because it involves such different aspects as behaviour, physiology and management. Important for the sake of animal welfare since technical solutions must be able to consider basic biological facts behind suckling (Lidfors *et al.*, 2001).

Compared to artificial calf rearing, suckling systems are more beneficial to the welfare of calves (Metz, 1987; Krohn, 2001; Vaarst *et al*., 2001). The calf will be nursed by the mother or a suckler cow, learn to eat roughage at a younger age, have social contact with other calves and cows and have space enough to exercise and play. Most of these factors are absent in artificial calf rearing systems (Krohn, 2001). So

with the current concerns about animal welfare and especially in organic production, it is a very interesting field to think about.

On many organic dairy farms, bull calves are sold to conventional farms and raised with conventional feed, because the husbandry system with organic artificial milk is so expensive or not possible because of other factors (like lack of stall capacity or shortage of own foodstuff; for a case in Denmark, see Nielsen and Thamsborg, 2002). In the Netherlands, nearly all of the about 13000 male organic calves are fattened till an age of 6-9 months on conventional farms (http://www.droevendaal.wur.nl/).

For this reason a project called "*Stierkalf waarding*" is carried out in Droevendaal farm. The aim is search for animal friendly solutions for rearing calves in biological farms.

One of the superior goals in organic farming is to provide all animals with optimal conditions and opportunities to express their natural behaviour, and to meet their natural needs. Consequently suckler systems, where the calves are kept with a cow seem a relevant solution. (Vaarst *et al*., 2001)

This thesis can be placed in the combination of these ideas: Raising beef calves that come from the dairy industry with one specific rearing management: a concrete suckling system with a nurse cow rearing different calves (*Multiple suckling system*).

In this chapter an introduction to general suckling systems for cattle, with their possible advantages and disadvantages will be discussed, based in a literature retrieval.

1.2. GENERAL OVERVIEW OF SUCKLING SYSTEMS

Lidfors and Jensen (1988) describe the natural behaviour of free-ranging cattle. They describe that in African and Camargue cattle, it has been reported that cows leave the herd a few days or hours before calving, probably because this lowers the risk of predation of the calf and facilitates imprinting between cow and calf. But in their study and others it has been found that only a few cows seek isolation at calving. This can be because of the effect of the domestication or because maybe cows are flexible in their behaviour. But, anyway, in free ranging and feral cattle, cow and calf stay together for several months (Krohn, 2001). The calf will suckle the dam from the first day and the cow will gradually wean the calf when it will be 8-12 months old or at least at birth of the next calf (Krohn, 2001).

But, on most North American and European dairy farms, calves are abruptly separated from their mothers within a few hours after birth (Flower and Weary 2003). This early separation of the calf from the cow is seen as a keystone of the modern dairy industry, and as essential to maximum production (de Passillé, 2001). Dams return to the milking herd while calves are artificially reared in isolation or in groups. Calves are fed rationed quantities of milk or milk replacer by bucket or bottle until weaning at approximately 4 to 12 weeks of age (Flower and Weary, 2003).

Producers suggest several reasons for separating calves early. One reason is on the economic ground: dairy farms make the money basically from selling the milk, so preventing the calf from suckling results, obviously, in more saleable milk for the producer. Calves must still be fed milk, however many farms feed "waste" milk (that which cannot be sold) or feed milk replacers that may be less costly than fresh milk (Flower and Weary, 2003)

Artificial rearing of calves allows for close monitoring of their food intake. Monitoring individual food intake allows producers to check for signs of health problems. In addition, artificial rearing when combined with feeding pasteurised milk or milk replacers may minimise the spread of some diseases. In the other hand, prepare the milk can cause problems due to an inappropriate hygienic level or the temperature of the milk that with a suckling system never occur (Vaarst *et al*., 1997)

Suckling is considered to inhibit a cow's return to oestrus or sexual receptivity. Many physiological and environmental factors affect this, but is thought that suckling has a major influence in delaying post-partum return to oestrus (Galina *et al*., 2001)

Preventing suckling is also cited to the cows to get used to machine milking, with a quick "milk let-down" reflex with minimal teat stimulation by the stockperson. Under conventional farm practice, cow milk let-down is rapid, but when cows are kept with calves, time to let-down may increase, doing machine milking less efficient (Flower and Weary, 2003)

Finally, producers argue on compassionate grounds that early calf removal minimises the stress of separation for both cow and calf. After parturition there appears to be a critical period for establishing the mother-infant bond. If prolonged contact is allowed between dam and calf, a stronger bond is established, making separation more distressing for both animals (see chapter 1.2.5.3)

Calves are very delicate animals, they are not just small bulls. They are mentioned a the most critical field in the organic herd (Vaarst *et al.,* 2000). Young calves are vulnerable to disease, often fail to gain weight and can sometimes experience high levels of mortality. Thus, their rearing system can have a big effect on subsequent behaviour (Dalton, 1999) and productivity.

1.2.1 Different types of suckling systems

Krohn (2001) in his review about suckling systems divide them in three different categories depending on the purpose and duration of the suckling period:

- *Long-term suckling without additional milking or Multiple suckling system.* This is usually a system where two to four calves have free access to suckle the cow day and night. It generally covers the period of nutritional need for milk of the calf, ranging generally from 6 weeks to 12 weeks. The cows are not milked during the pre-weaning period but only post-weaning.
- *Long-term suckling with additional milking*. Here the cows usually machine milked and calves have access to suckle the cow in only a few daily periods of 15 – 30 min. This is also called restricted suckling system

- *Short-term suckling*. Suckling is only allowed during a short-term period just after calving (from 24 hours to 3 days) when the calf have a good chance of obtaining colostrums by suckling.

In the first system nurse cows are usually used, while in the other two is usually the mother who rear her calf.

1.2.2 Weight gain

In several studies comparing suckling systems results show that live weight gain can increase significantly (Gaya, 1977; Spinka and Illman, 1991; Sanh *et al.*, 1995; Bar-peled, 1997; Mejia *et al.*, 1998; Weary, 2002). In Flower and Weary, 2001) comparing calves separated at different ages from the mother was found that calves separated later took and advantage in weight during the rearing period and this advantage was maintained even after weaning. Metz (1987) also found much higher gains for calves kept with cows for 10 days after birth, and reported that these weight differences persisted for more than two months in some instances.

Various reasons are cited for the increase of weight gain. One reason is probably because the calves suckle more frequently and drink more milk when they stay with the mother. Flower and Weary (2001) found that calves allowed to suckle freely on the cow for two weeks after birth gained weight at over three times the rate of calves separated early and fed a restricted quantity of milk twice a day.

Shamay *et al*. (2004) compared calves reared with milk and with milk replacer. They also found a difference in the growth of calves. This is probably because the milk gives the calves in addition to its energy, protein, and mineral content, milk from the dam also includes growth factors, such as IGF-I, IGF-II, and IGF-binding proteins, as well as mammary-derived growth inhibitor and also other components (in Bar-Peled, 1997).

Improved health (see chapter 1.2.4) is another reason of the increased weight gain of the suckling calves (Moss, 1977; Metz, 1987). Obviously, healthy calves will grow faster than calves with diarrhoea or other problems.

In the review of Krohn (2001) high daily gains are reported for long-term suckilng systems (with and without additional milking). It is also reported that compared to bucket-fed calves, multiple suckling leads to greater individual variation in gain, especially if the initial live weight of the calves differs. In short term-suckling differences were found but more from the presence of the dam, concluding that social interaction between cow and calf in the colostrums period had a positive effect on the daily gain of the calf.

It is also reported (Sanh *et al*., 1995) that calves suckling directly and slowly from their dam take advantages for their digestive tract. When calves are suckled naturally, milk is channelled by the reticular groove reflex directly to the abomasum, which is the true stomach of a newborn calf. Both energy and protein are utilized with considerably greater efficiency than if the milk had first passed into the rumen. When drinking milk from a bucket, it is probable that a part of the milk enters the rumen.

1.2.3. Feed intake

A high daily gain through a high milk intake is not necessarily beneficial, because it results in a decreased intake of roughage, and hence delayed rumen development, and increases difficulties associated with weaning-separation (in Krohn, 2001).

It is the general thought, but for Weary (2002), this procedure is a fallacy. In his experiments he has found that ad libitum calves quickly caught up to the conventionally-fed calves in their intake of starter after weaning, consuming both groups similar quantities of concentrates after two weeks.

Flower and Weary (2001) comparing calves separated from the dam just after birth (early-separation) or 2 weeks later (late-separation) observed that late-separation suckling calves were more frequently ruminating by two weeks of age and were eating more solid feed than non suckling calves. On the other hand, on the study of Bar-peled (1997) suckling calves (for 6 weeks) did not consume concentrates or hay during the suckling period, although these were available. For this, calves decreased sharply during week 7 (weaning) suggesting a greater stress as the result of weaning and adjusting to solid feed. The bucket-fed calves also showed a decreased growth, however was less compared to the suckling calves.

In Langhout (2003) it is also reported a Danish study of Jonasen and Krohn, where calves that were allowed to suckle twice a day ate very little concentrates after weaning compared to the calves removed immediately after birth. They had also difficulties in changing from large quantities of milk to only concentrates and hay, which impaired the growth for the first three weeks after weaning. However measured over the whole period after weaning (42 till 101 days) there was no difference in feed intake.

1.2.4. Health of calves

1.2.4.1. Colostrum

Newborn calves have no antibodies against neonatal infections. Thus, for immunological protection, they are entirely dependent on their mother's colostrums (in Flower and Weary, 2003). Within the first 24 hours after birth, a large quantity of immunoglobulins (Ig) is transferred when calf suckle the colostrums from its dam. The ability to absorb Ig decreases gradually with time after birth. Several factors influence the absorption of Ig, the most important being calf age and the quantity of colostrums ingested.

Selman and colleagues (1970, in Flower and Weary, 2003) discovered that the presence of the dam during the Ig absortive period has a positive effect on absorption efficiency, perhaps because the cow stimulates the calf to stand and suckle earlier (Le Neindre, 1989)

Some calves, however, may not suckle within the critical period of 24 hours after birth. Lidfors (1996) found that about 30 % of calves failed to suckle within 4

and 6 hours after birth. Thus, producers need to ensure that all calves receive colostrums soon after birth either by guiding the calf to the teats or by bottle-feeding.

There may be positive effects associated with continued colostral intake in the days after birth. In the experiment of Weary and Chua (2000), calves kept with cows for 4 days had fewer cases of diarrhoea during three weeks of life than calves separated earlier (6 or 24 hours), despite the fact that all calves were bottle-fed colostrums within 24 h of birth.

Also in Flower and Weary (2003) other positive health effects of maternal contact are described. For example, mother reared calves defecate and urinate earlier after birth, as a result of frequent licking bouts; the early removal of the meconium (first excretion) by dams promotes colostrum intake and digestive functions of the calf, important for health and survival.

1.2.4.2. Milk

Like colostrum, milk contains antibodies, including important ones directed specifically against organisms with which the cow has been infected and which may be present in the particular local environment. These antibodies are thought to coat the mucosal surfaces lining the gut and prevent invasion by ineffective organisms. Milk also contains cells of several types which are important for immune responses, including lymphocytes capable of reacting directly with antigens to which the cow has been sensitized. Other non-specific agents are also present, which inhibit the multiplication of micro-organisms. Although many of these factors remain in fresh milk, drying it destroys them (Ryle and Orskow, 1990).

As said before, artificial rearing, when combined with feeding pasteurised milk or milk replacers may minimise the spread of some diseases. But preparing the milk can cause problems due to an inappropriate hygienic level or the temperature of the milk that with a suckling system never occur (Vaarst *et al*., 1997). In Moss (1977) the artificial reared calves growth was less than suckled calves and he discuss that one of the reasons is the scouring (diarrhoea), and that is probably due to low hygiene or to the quality of milk replacer. Thus, a risk of infection is increased simply handling the milk (Ryle and Orskow, 1990). Furthermore, milk antibodies and cells can possibly attach to the surface of the bucket, so less are available to coat the gut mucosa (Ryle and Orskow, 1990).

1.2.4.3. Behavioural strategies

Behavioural strategies for health offer the potential for providing sustainable health care for animals. When young animals grow up with their mother and animals of their own age they get the opportunity to learn from them. Mammals have an opportunity to learn the taste and smell of safe foods while in the uterus, an later from their mother’s milk, as well as by sampling what she is eating. While some people focus only on the destruction of pathogens, animals fight infectious disease via a holistic approach that involves avoidance, prevention and treatment of disease (in Langhout, 2003).

1.2.5. Behaviour

1.2.5.1. Sucking motivation and related problems

Since survival of the young mammals depends on sucking success, it can be assumed that sucking motivation must be strong and that sucking deprivation would result in frustration which could have a negative impact on their welfare (de Passillé, 2001).

Cross-suckling (sucking of ears, tails, prepuce and other body parts) and inter-suckling (milk stealing and udder sucking in older animals) are often seen between calves artificially reared (Veisser *et al*., 2002), because they are forbidden to express this natural behaviour.

1.2.5.2. Social interaction

In Vaarst (2001) it is concluded that calves that spent their colostrum period with their mother are more socially active than the bucket fed calves, when confronted with a nurse cow.

In Flower and Weary (2001) is found that calves from a late-separation group (2 weeks) were more interactive than from a early-separation (1 day). So it seems that mother-reared calves shows higher levels of social activity than calves separated soon after birth (Flower and Weary, 2003).

Thus, maternal presence is important for social learning and decreses fearfulness of others. Keeping the calf with the cow in the maternity pen may allow for the development of a more comprehensive social repertoire in calves, providing an advantage when the calf is eventually introduced into a group.

1.2.5.3. Cow-calf bond

When a young mammal is separated from its mother at weaning, a number of responses are typically observed, the animals often becomes more active, and much more vocal, especially during the first 24 h after separation. A period of weight loss, or a slowing in the rate of weight gain, is also often observed, accompanied by variable intakes of food and water. The animal also becomes more susceptible and digestive upset. The mother sometimes shows a similar response, including increased activity and vocal behaviour. (Weary and Chua, 2000)

This “cow-calf bond” seems that appear after as little as 5 min of contact between calf and dam after birth (Weary and Chua, 2000). There are contradictory results, most of them from dairy cattle, about the stress that may be generated by the separation of the calves from their mother, which varies according to the age of the calf or the degree of separation. For example, in the study of Weary and Chua (2000), comparing calves separated at 6 h, 1 day or 4 days after birth, it seems that the response is more acute. But Lidfors (1996) found no difference in calf response between those separated at 4 days after birth and those separated after just a few hours whit the cow. And also, in the review of Galina (2001), it is stated that with later ages,

with the removal of the calf, the accompanying sensory information fades and stress may be reduced.

In Veisser (1990) behavioural studies report that weaned calves gather and have more social encounters among each other than calves which remain with their dams. This led us to conclude that weaning strengthened bonds between calves. It was also seen for Sato (1987) studying "crèche" behaviour, who conclude that a possible function of forming crèche groups is weaken maternal bonds and reinforce social bonds.

1.2.6. Welfare

Welfare is a difficult equation between many factors. Housing, feeding and handling are three important factors (Krohn, 2001), and all three are affected in different rearing systems. Different types of management tend to produce different welfare problems and changing management systems often result in switching from one set of welfare problems to another (de Passillé, 2001).

Housing calves in group pens, in conditions of increased movement and social relationship, comparing with traditional housing with tethers in individual stalls seem to improve the welfare (Xiccato *et al.*, 2002), despite some possible problems of cross-suckling.

The issue of behavioural deprivation is central to animal welfare, since in most modern farms, the animals cannot perform many of the behaviours regularly seen in less restrictive environments (de Passillé, 2001). For this, given the importance of suckling in natural conditions and the behavioural problems when suckling is forbidden, it seems that suckling systems in general are more beneficial for the welfare of the calves.

Also improved health and production seems to be an indicator of better welfare. Judging the best for the animal welfare will require a balancing of all these factors.

1.3. OBJECTIVES OF THIS STUDY

Placing in the idea of the project "Stierkalf waardig" of Droevendaal farm to search solutions for rearing organic calves in an organic way, and taking into account that the first rearing system with artificial milk resulted too expensive, the objectives of this study can be summarised in the following research questions:

- Do suckling systems give economical benefits compared to artificial rearing?
- Does the calf growth rate increase in the case of suckling systems?
- Can we identify an increase in the naturalness and animal welfare in the suckling system?

2. MATERIALS AND METHODS

2.1. THE FARM

This project has been carried out in the experimental farm "*Biologisch Proef- and Leerbedrijf Droevendaal*" (Organic Research and Educational Farm *Droevendaal*), that belongs to Wageningen University and Research Centrum. This is a multifunctional farm, with about 50 ha of fields and different types of animals (steers, pony's, chicken, ducks…) where research is done, following the organic principles.

Several crops are produced in the farm. Some of them were used as feed in our experiment. Hay and corn silage are produced and stored in the farm and are part of the ration given to the calves and cows. Carrots produced had not enough market and also were included as feed for the animals. Other products had to be bought.

2.2. THE ANIMALS

All the cattle in this farm are for a beef purpose. The steers of the farm come from *Aver Heino*, an organic experimental dairy farm. The calves are all a crossbred between Holstein-Friesian and an old Dutch bred (MRY – "Maas-Rijn-Yssel vee").

Identification number	Sex	Skin colour	Birthday date	Other characteristics
8133	M	Brown-white	07-11-2004	
8134	M	Brown-white	10-11-2004	Twin
8135	M	Brown-white	11-11-2004	Twin
8136	F*	Brown-white	11-11-2004	Twin
8137	M	Brown-white	12-11-2004	
8138	M	Brown-white	12-11-2004	
8142	M	Brown-white	22-11-2004	
8143	M	Brown-white	24-11-2004	
8144	M	Brown-white	26-11-2004	
8145	M	Black-white	29-11-2004	
8071	M	Brown-white	29-11-2004	
8072	M	Black-white	05-12-2004	
8076	M	Brown-white	26-12-2004	
8077	M	Brown-white	09-01-2005	
8078	M	Brown-white	24-01-2005	
8079	M	Black-white	25-01-2005	
8080	M	Brown-white	28-01-2005	
8081	M	Brown-white	28-01-2005	
6181	F (cow)	Black-white	29-05-1998	
7181	F (cow)	Brown-white	30-11-2001	

Table 1. Animals involved in the experiment

* This calf is a female, and is here, because she is a twin, and when twins of different sexes grow in the uterus of the dam, the female become androgenized by the hormones of the male and become sterile, so it cannot be a heifer for replacement.

The calves born in *Aver Heino* are kept with its mother for 2 or 3 days to take the colostrum from her. After this, they are separated from the mother and fed with powder milk. From an age of 10 days calves can be sold and is from this age that they arrive to *Droevendaal* farm. In table 1 the main characteristics of the animals of the experiment are presented.

The aim of the experiment was to compare the productive results of calves fed with artificial milk and calves kept with a suckler cow. So, with the setting up of the experiments the farm had to acquire "nurse cows". Two cows were bought, also a crossbred between Holstein-Friesian and *MRY vee*.

2.3. THE EXPERIMENT

2.3.1. *Planning*

Four groups of three calves (n=3) were made taking into account age and live weight, to get four comparable groups as homogenous as possible. Two groups – the control groups- were fed with artificial milk, and the other two –experimental groups- stayed with a nurse cow each one.

After this experiment finished, it was seen the possibility to arrange another repetition with one of the cows participating in the first trial. So, when the cow finished of rearing the first group, another group (n=3) was introduced and a control group (n=3) was also established. In figure 1 the stable can be seen.

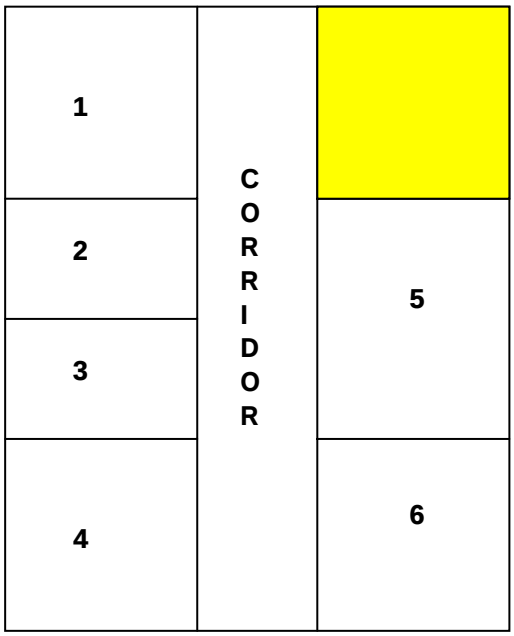

Fig 1. Stable where the experiment was carried out. Cages 1, 4, 5 and 6 have 21 m^2 and cages 2 and 3 10,5 m^2.

In the first trial the groups were:

- cage 2: non-suckling group 1, with calves: 8133,8134 and 8137
- cage 5: suckling group 1, with: cow 7181 and calves 8135, 8136 and 8138

- cage 3: non-suckling group 2, with calves: 8071, 8072 and 8142
- cage 6: suckling group 2, with: cow 6181 and calves 8143, 8144 and 8145

In the second trial the groups were:

- cage 2: non-suckling group 3, with calves: 8076, 8078 and 8079
- cage 5: suckling group 3, with: cow 7181 and calves 8077, 8080 and 8081

The experimental period started the 1st of December 2004 with the set up of group 1. It lasted 13 weeks, till the 2nd of March 2005. The second group started with three weeks of delay (because of the arrival of the second cow and the calves), starting the 22nd of December 2004, during also 13 weeks, so it finished the 23rd of March 2005. Group 3 started just following group 1, so the 3rd of March 2005, during, this one, 11 weeks, so it finished the 18th of May 2005.

Every group of calves was reared together in a cage. The solid feed was given commonly for the three calves and in the suckling group the three calves were competing for the milk. Then, the growth of each calf in a group depends also of the other two calves. For this, the experimental unit considered was the group of three calves.

2.3.2. Measurements

In *Droevendaal* farm all calves are weighed every 2 weeks. But for our experiment the calves, and also the cows, were weighed once a week, every Wednesday morning from the start of the experiment until the end, that is when the calves were weaned.

Milk production follows a theoretical lactation curve, which in case of little periods, can be adjusted to a linear approximation. For this, the cows were hand-milked at the beginning and at the end of each trial, and drawing a straight line between the starting production and the final one, the milk intake during the period could be estimated. For the control groups the amount of powder milk given to the calves was measured. The routine was giving them artificial milk two times per day. For the first two weeks 2 litres of milk were given each time. From the day 14 till the weaning, 3 litres of milk were given each time.

In tables 2 and 3 the standard ration given to the animals, in both trials, can be seen.

Cages 2 and 3: 3 calves – *2 times per day*	
Artificial milk	0 – 14 days: 2 l milk/time/animal
	14 days – weaning: 3 l mile/time/animal
Concentrates (*krachtvoer*)	2 kg/time (if it's finished)
Crushed wheat	2 kg/time (if it's finished)
Hay	*Ad libitum*

Table 2. Non-suckling group ration.

Cages 5 and 6: 1 cow + 3 calves – *2 times per day*	
Carrots	2 shovelful/time (that is about 7,5 kg/time)
Concentrates (*krachtvoer*)	2 kg/time
Crushed wheat	2 kg/time
Corn silage	2 shovelful/time (that is about 10 kg/time)
Hay	*Ad libitum*

Table 3. Suckling group ration.

Concentrates and crushed wheat was mainly for the calves, and carrots and corn silage was specifically for the cows. Hay was given *ad libitum* for both calves and cows.

Behavioural and health aspects were not included specifically in the planning of the experiment, but any serious problem or abnormal behaviour were controlled by the farmers. Records were kept daily on the status of the animals.

2.4. DATA ANALYSIS AND STATISTICS

The results obtained of the calf growth were analysed with Microsoft Excel 2003 and SPSS 12.0. Theoretical growth rates of the experimental units (groups) were calculated. Considering the three trials as replications of the comparison between suckling groups and artificial-fed ones, differences between the two systems were tested using an Independent Samples T-test.

3. RESULTS

3.1. WEIGHT GAIN

All weights collected during the experiment can be seen in the appendices. Also calculated weight at 30, 45, 60, 75, 90 and 105 days are exposed in the appendices. Weaning was, on average, at day 115, ranging from day 107 to 137. For the analysis weaning age was considered at 105 (taking into account that minimum age at weaning was 107).

In figures 2,3 and 4 it can be seen the average calf growth of each group from day 30 to 105 (where the data is available) for groups 1 and 2 from trial 1 and from trial 2, respectively.

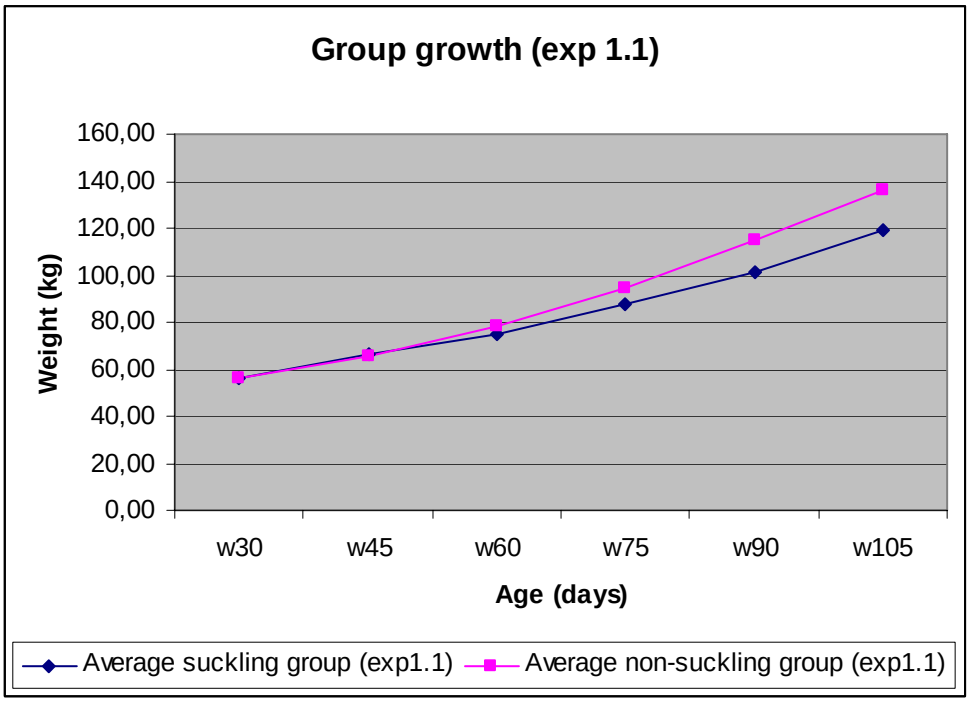

Fig 2. Average growth for groups of experiment 1.1

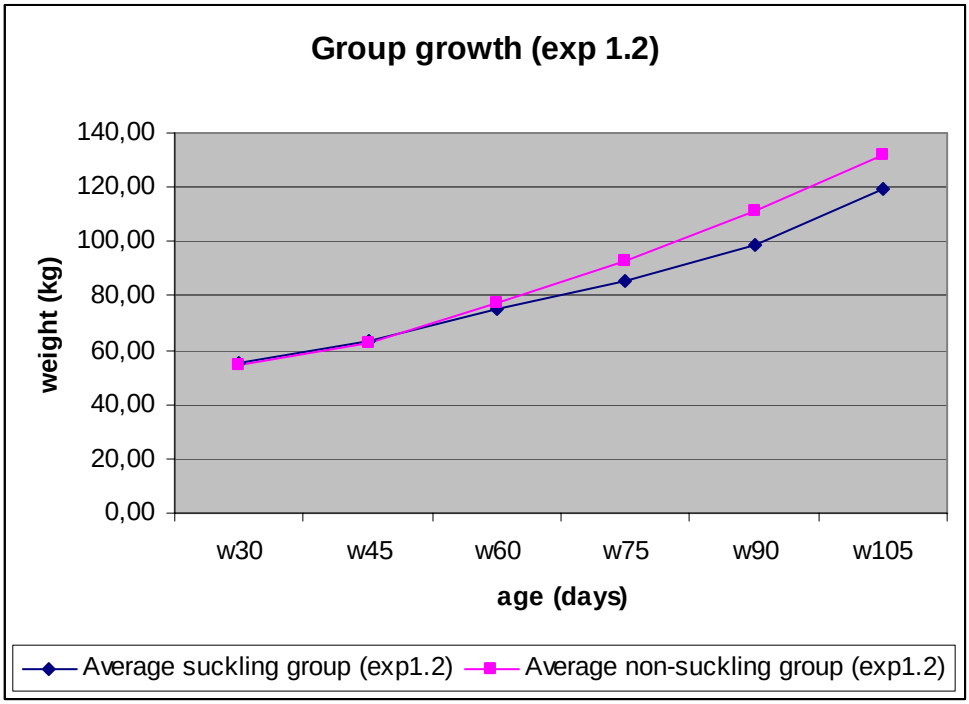

Fig 3. Average growth for groups of experiment 1.2

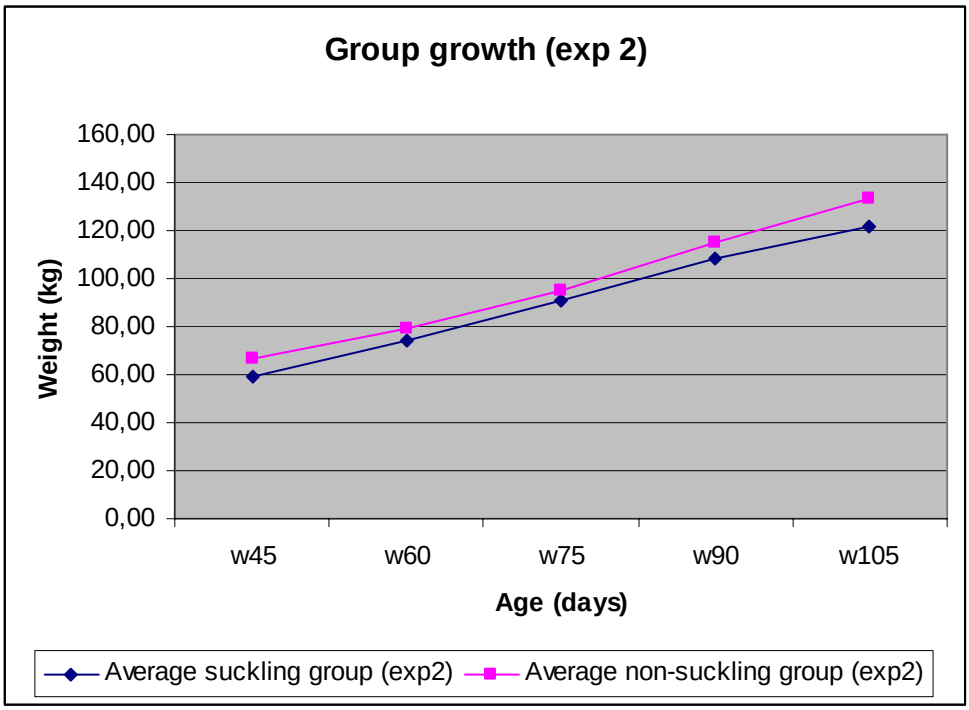

Fig 4. Average growth for groups of experiment 2

Figure 5 shows the growth for the average weight of calves from the two systems (from available data at each age).

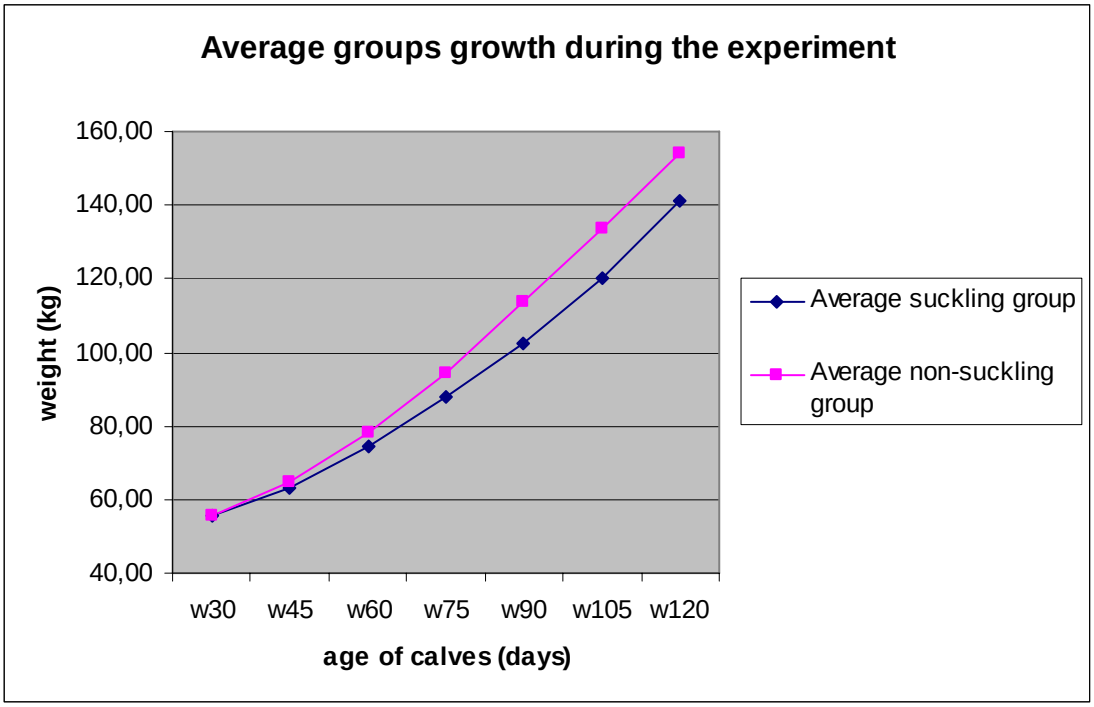

Fig 5. Average growth for the two rearing systems

Average group weight at different ages was used to calculate the theoretical growth rate of the experimental units. Exponential growth resulted to be the curve that fits better to this growth. In next figures calculated growth rates can be seen:

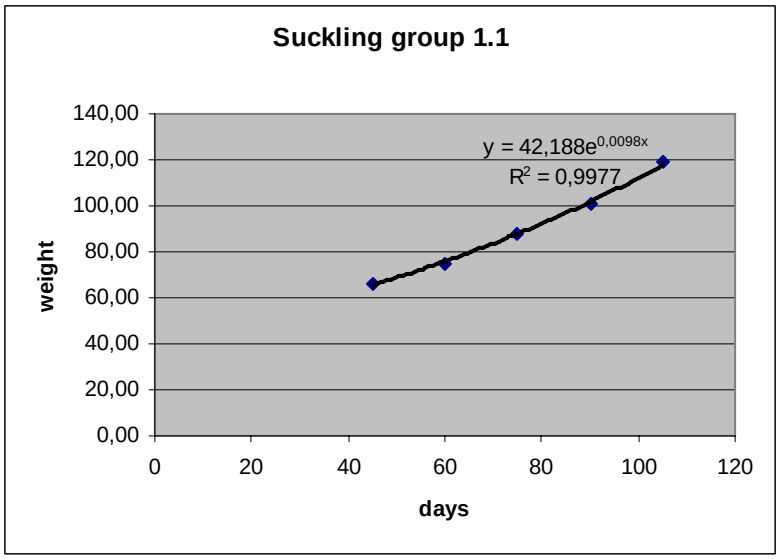

Fig 6. Theoretical growth rate for suckling group 1.1

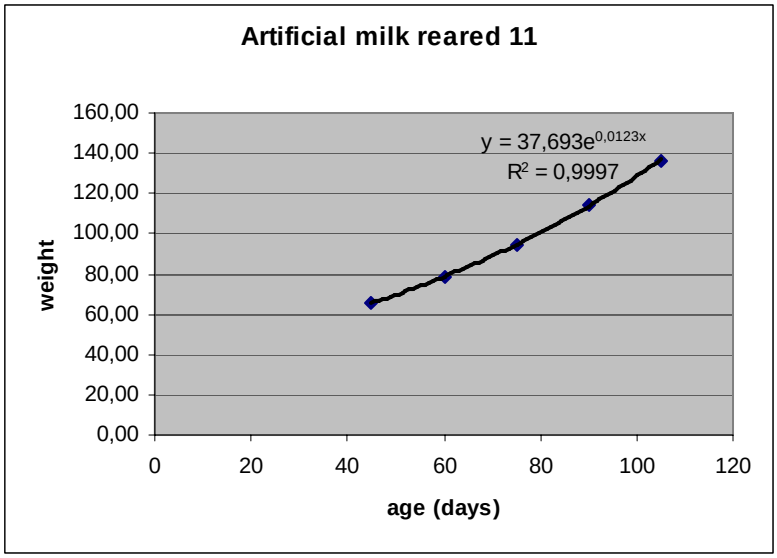

Fig 7. Theoretical growth rate for bucket-fed group 1.1

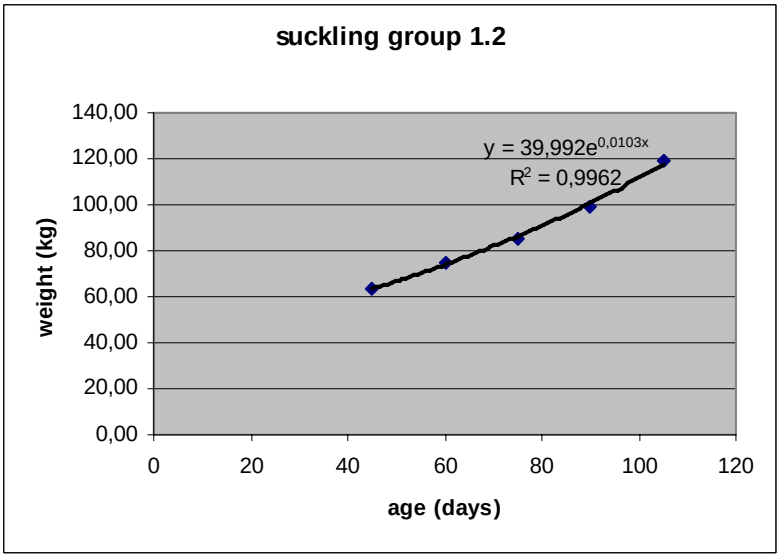

Fig 8. Theoretical growth rate for suckling group 1.2

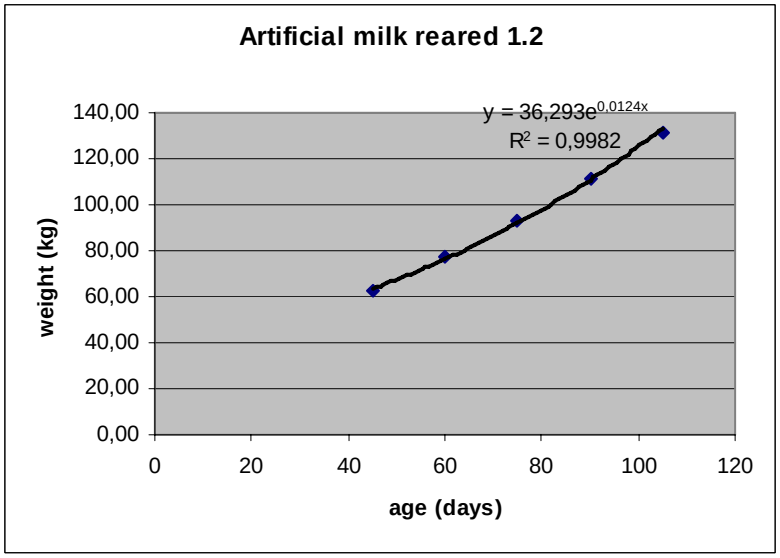

Fig 9. Theoretical growth rate for bucket-fed group 1.2

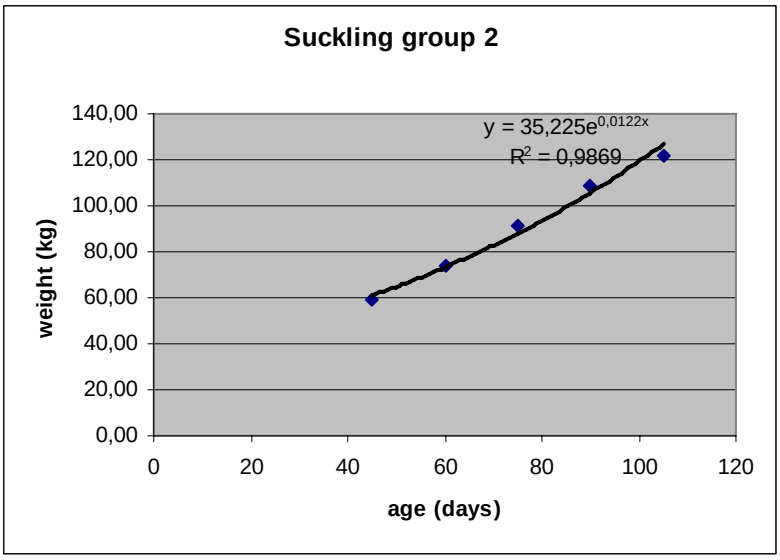

Fig 10. Theoretical growth rate for suckling group 2

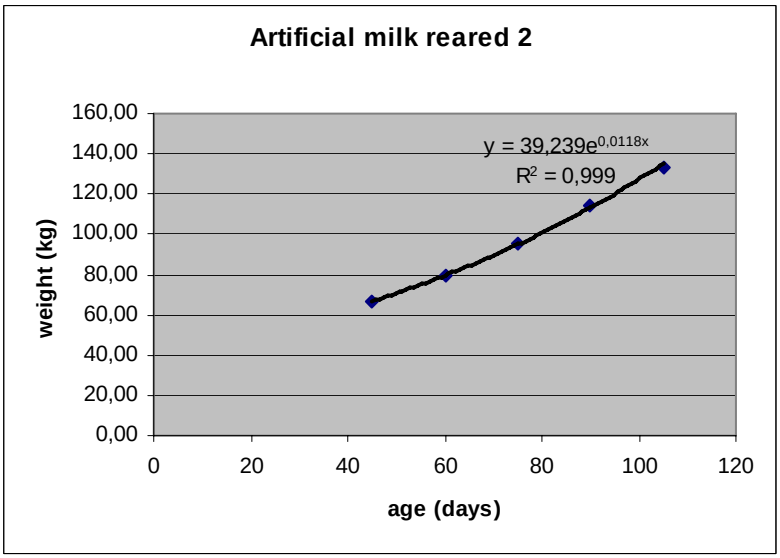

Fig 11. Theoretical growth rate for bucket-fed group 2

Exponential growth follows the general model $Y = b_0 * e^{b1*t}$, where in this case:

Y = Weight of the calf at time t (kg)
b_0 = Initial weight (kg)
b_1 = Growth rate (kg/day)
t = time (days)

Once calculated the different growth rates (b_1) for each group where tested for significant differences between the suckling system and the bucket-fed system. The differences of growth rates were not significant but there was some tendency (P = 0,141)

3.2. POST-WEANING GROWTH

Some data of the post-weaning growth for trials 1.1 and 1.2 was finally available and was also included in the analysis. In figure 12 we can see the average calf growth in the post-weaning period till 180 days for suckling and non-suckling calves.

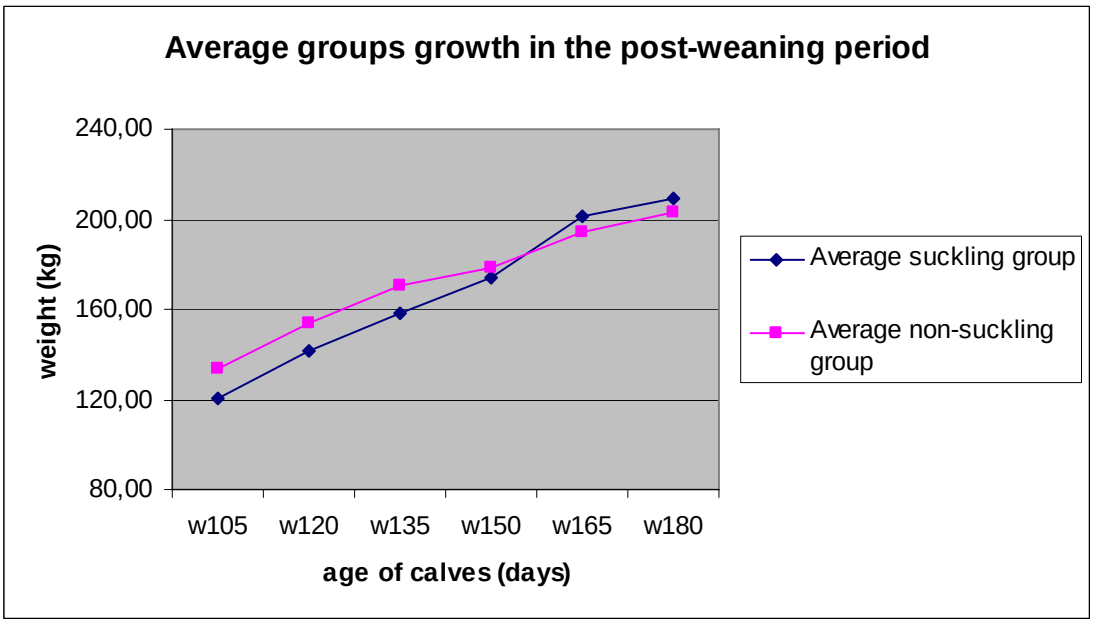

Fig 12. Average calves growth for the two systems in the post-weaning period

3.3. HEALTH AND BEHAVIOURAL ASPECTS

No abnormal behaviour was observed during the experiment. Both cows let the calves suckle from the first day. Only some butting against the calves in the time of giving the feed was observed. Cow 6181 showed difficulties for its management and for this reason was sold after the experiment. In the other hand, cow 7181 was considered to have good maternal behaviour and good characteristics for its management and for this reason is still in the farm.

During the experimental treatment only a few health incidences were reported. On the 7th of January calves 8135 and 8136 (both from first suckling group on cow 7181) were treated with 5 cc of NuFlor®, a general treatment, in this case for lung problems (difficulties in breathing). Calf 8072 (from non-suckling group in the second trial) was identified to have an infection in the umbilical cord. It was treated with 10 cc of NuFlor®. It seemed that the problem was solved but on the 20th of March it was again treated with 10 cc of NuFlor® for three days because of an abnormal breathing. Finally it required veterinarian intervention, and was treated with Droprim®. After the experimental period this calf died (4th of April). Calf 8081 was also treated with NuFlor® because of diarrhoea, but it was just before it was included to the experiment (1st of March).

3.4. MILK PRODUCTION AND WEIGHT OF THE COWS

Milk production of the cow was estimated by hand-milking the cows at the beginning and the end of the trials. Cow 6181 (calved on 27/07/04, being the 4th lactation) started the experiment producing about 16 litres of milk, ending with about 13 litres. This means that the total production on the experimental period was about 1319,5 litres (14,5 litres/day on average).

Cow 7181 (calved at 30/09/04, being the second lactation) started with about 21 litres/day of milk (probably near to her peak of lactation) and ended the first experiment producing 15 litres, that were maintained during the second trial. It means that the cow produced about 1638 litres (average of 18 litres/day) on the first trial (91 days) and 1155 litres during the second trial of 77 days.

The weight of the cows during the experiment was changing but always around the initial weight, finishing one cow (7181) with approximately the same weight and the other even higher than the initial weight. Weight variation during the experiment can be seen in figure 13:

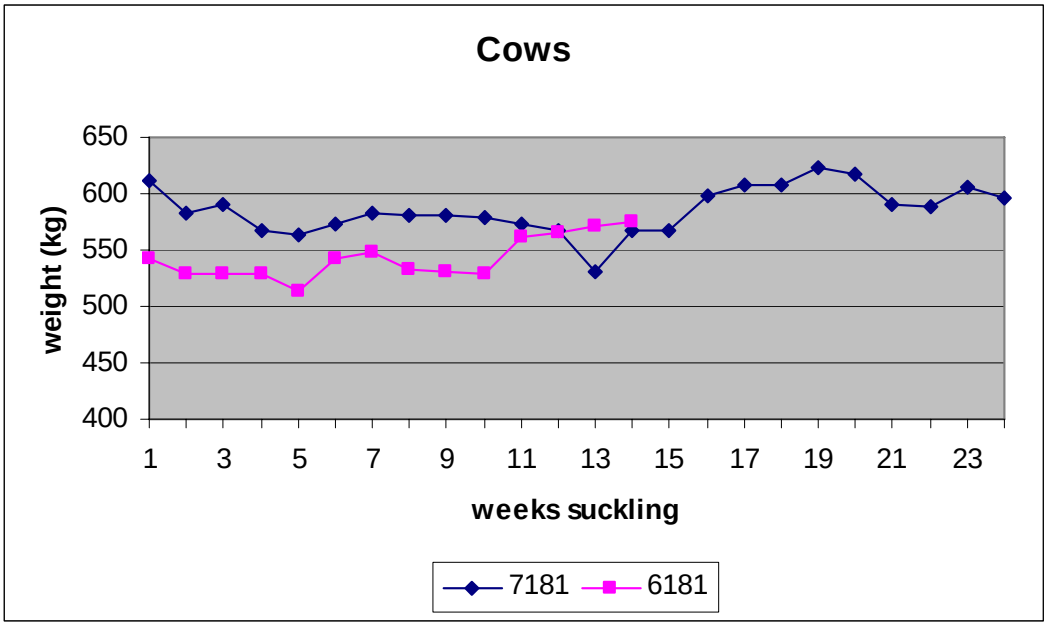

Fig 13. Weight change for the cows during the experiment.

3.5. ECONOMICAL ANALYSIS

Doing an economical analysis in a farm where almost all the feed is produced in it and the staff is doing also other things is not an easy task. For this we had to base our analysis in direct costs and make some estimation. Feed costs are summarized in the next tables:

Carrots (2,20 ha, produced in the farm)	
Seeds for sowing	2242,96 €
Prepare de soil + sowing	922,20 €
Harvesting	2895,79
Estimation working hours (weeding…)	252 h x 6,5 €/h = 1638 €
Production	201000 kg
Conservation	37,5 € per 1200 kg → 6281,25 €
TOTAL COSTS	13980,2 €
COST	**0,0696 €/kg**

Table 4. Costs of carrots produced in the farm

Corn silage (3,50 ha, produced in the farm)	
Seeds for sowing	894,64 €
Estimation costs for sowing	100 € per ha → 350 €
Making the silage + black plastic	1309,10 €
Production	27700 kg/ha
TOTAL COSTS	2553,74 €
COST	**0,0263 €/kg**

Table 5. Costs of corn silage produced in the farm

Wheat (bought)	
Price paid	201,4 € per 1000 kg
COST	**0,201 €/kg**

Table 6. Costs of bought wheat

Hay (produced in the farm by own workers)	
Estimation total costs	85 € per 1000 kg
COST	**0,085 €/kg**

Table 7. Costs of hay produced in the farm

Concentrates (Power fodder *Eureko Kalverkorrel*)	
Price paid	39,22 € per 100 kg
COST	**0,392 €/kg**

Table 8. Costs of bought concentrates

Powder milk (*Zelmo blue bio kalverdrank*)	
Price paid	255,46 € per 100 kg
COST	**2,55 €/kg**

Table 9. Costs of bought powder milk

The main difference between groups is their source of milk. In the control group they are fed with artificial milk, and in the experimental one is the cow who feds the calves. So the maintenance costs of the cow and the powder milk costs are the basic difference in costs of rearing the calves.

Each litre of artificial milk is done with 142,8 grams of powder milk. Thus, the powder milk needed for rearing the calf is:

- For the first 14 days: 142,8 g/l x 2 l x 2 times/day = 571,2 g/day
- From day 15 to weaning: 142,8 g/l x 3 l x 2 times/day = 856,8 g/day

For the first two groups of calves the experimental period lasted 13 weeks (91 days). The second group stayed 10 weeks (70 days) in the experiment. It means:

- First trial: (14 d x 571,2 g/day) + [(91-14) d x 856, 8 g/day] = 73970,4 g
  So the costs are: 73,97 kg x 2,55 €/kg = 188,62 €/calf → 565,86 €/group

- Second trial: (14 d x 571,2 g/day) + [(70-14) d x 856, 8 g/day] = 55977,6 g
  So the costs are: 55,98 kg x 2,55 €/kg = 142,75 €/calf → 428,25 €/group

The main costs of maintenance of the cow are the feed she eats. If we take the standard ration for the cage of the cow and the calves, we can assume that the cow eats all the carrots, all the corn silage, more than 75% of the concentrates and wheat and about 8 kg of hay per day (estimations made by the farmers). Thus, the daily costs of feeding the cow are:

- 15 kg carrots x 0,0696 €/kg = 1,044 €
- 20 kg corn silage x 0,0263 €/kg =0,526 €
- 3 kg wheat x 0,201 €/kg= 0,603 €
- 3 kg concentrates x 0,392 €/kg = 1,176 €
- 8 kg hay x 0,085 €/kg = 0,68 €
- TOTAL DAILY COSTS = 4,029 €/day
  - Costs for the first trial: 91 days x 4,029 €/day = 366,6 €/cow
  - Costs for the second trial: 70 days x 4,029 €/day = 282,0 €/cow

The price paid for acquire the cows were € 500 for cow 6181 and € 800 for cow 7181. Cow 6181 was sold after the first trial for € 350. Cow 7181 is still valued around 800 euros, taking into account that her weight has not changed and she has the same characteristics than in the beginning. Cows had to be brought from other farms. Cow 7181 came also from Aver Heino and was transported with together with some calves. Cow 6181 came from another farm located nearer than Aver Heino. Total costs of transportation can be estimated as € 80 per cow. Cow 7181 reared calves in trial 1 and in trial 2 and also one more after the experiment finished. For this transportation costs can be divided between the grups (€ 27)

No vet treatments or requirements were needed during the experiment.

We can also estimate the difference of time for maintaining the two groups. One group requires feed the calves with solid feed and with artificial milk, and the other feed the calves and the cow with solid food. We can estimate a difference of 5 minutes more per time for the non-suckling group than for the suckling one.

Taking a price of 7 €/h for a standard worker, it means:

- First trial: 5/60 hours x 2 times/day x 91 days x 7 €/hour = 106,17 €/group
- Second trial: 5/60 hours x 2 times/day x 70 days x 7 €/hour = 81,67 €/group

In tables 10, 11 and 12 costs for trial 1.1, 1.2 and 2, respectively, are summarised:

Suckling group		**Non-suckling group**	
Feeding the cow	€ 366,6	Artificial milk	€ 565,9
Cost of the cow	0	Extra labour	€ 106,2
Transportation of the cow	€ 27		
Total	***€ 393,6***	***Total***	***€ 672,1***
Total/calf	***€ 131,2***	***Total/calf***	***€ 224***

Table 10. Costs of trial 1.1 (91 days)

Suckling group		**Non-suckling group**	
Feeding the cow	€ 366,6	Artificial milk	€ 565,9
Cost of the cow	€ 150	Extra labour	€ 106,2
Transportation of the cow	€ 80		
Total	***€ 596,6***	***Total***	***€ 672,1***
Total/calf	***€ 198,9***	***Total/calf***	***€ 224***

Table 11. Costs of trial 1.2 (91 days)

Suckling group		**Non-suckling group**	
Feeding the cow	€ 282	Artificial milk	€ 428,3
Cost of the cow	0	Extra labour	€ 81,7
Transportation of the cow	€ 27		
Total	***€ 309***	***Total***	***€ 510***
Total/calf	***€ 103***	***Total/calf***	***€ 170***

Table 12. Costs of trial 2 (70 days)

4. DISCUSSION

There are a lot of ways of rearing calves. Different types of artificial rearing (bucket, teats, automatic devicer…), different types of milk (fresh, skimmed, powder), different ages at weaning and different types of suckling systems are possible. In the case of Droevendaal farm, the bucket feeding with powder milk, is the most common procedure in intensive feeding. But in organic production is a very expensive option, if the weaning of milk is at three months, and suckling systems claim for better welfare and possibilities to express natural behaviour.

In many cases of extensive beef production suckling is the option for rearing calves, because cows are left in fields where they graze most part of the year and calves are born there and the function of beef cow's milk is rear the calves.

For this the main part of the studies of suckling systems are about dairy farms and in great part of the cases looking the calf as a future heifer. So, it lacks research about suckling as an option for rearing male calves for beef production.

As commented in the introduction in organic production is very difficult to rear calves coming from dairy farms and for this in Droevendaal the *Stierkalf waardig* project was initiated. But the option was rear the calves with the bucket system.

It can be said that is the first time that such an experiment for the comparison between suckling and bucket systems is done. Thus, this project is a first approximation to the profitability and productivity of a suckling system used for rearing male calves that come from dairy farms.

Taking into account that the farm is only for a beef purpose, restricted suckling systems have no sense, because in the farm there is no milking machinery and it would not be worth. One cow have milk for more than one calves and multiple suckling seems to have advantages for the post-weaning growth (van Leeuwen, 2004). For this the idea of a multiple suckling system with a nurse cow may be the better option in our case.

In our case there were no difficulties for the calves to adapt to suckle the nurse cow. It has been reported that the most important thing to success in that system is the previous experience of the calves (Vaarst, 2001), and in the case of organic steers, they have to be at least a few days with the mother after birth, so they get the experience to suckle.

4.1. CALVES GROWTH

Great part of the previous studies about suckling systems agrees that suckling have a lot of potentiality for calf growth (Gaya, 1977; Bar-peled, 1997; Weary, 2002). In our experiment the results till weaning seem to be the contrary. Even no significance was found between growth rates from two systems, there is a tendency to it, and we can see that all growth rates of bucket-fed calves are higher than the ones of suckling groups.

Several explanations for these results can be drawn. As we said in chapter 1.2.2., one of the main reasons for the better growth in suckling systems is that they generally allow a higher amount of milk. But in this case it was not like this. Calves reared with powder milk received from week 3, six litres everyday. Cow productions were low, and they allow similar or even less milk than in the control group. Cow 6181 gave 14,5 litres/day on average, that is 4,8 litres/calf/day, and cow 7181 started with 18 litres/ on average, that is 6 litres a day for each calf, and in the second trial 15 litres a day, that is 5 litres per calf.

Furthermore, these are averages, and in fact, the quantities had decreased during the experiment while calf needs increases. For these if we look at weight increase of the average of groups in experiment 1 (figs 2 and 3) it can be seen that in the first weeks suckling group did not differ from the control group (even a slight better growth), but from around day 50 the control group growth became higher till weaning.

But maybe another reason it is also more important. While in the non-suckling group the solid feed intake was controlled and given almost *ad libitum* in the suckling group the solid feed had to be shared with the cow. Observations of the cow butting against the calves were reported. And also, with the estimations of the farmers that cow take probably more than 75% of concentrates and grain, in the suckling group the estimated total amount of concentrates and wheat taken by the calves were about 90 kg, compared to the approximately the double for the non-suckling group (171 kg of concentrates and wheat for the first group, 218 of concentrates and 214 of wheat for the second and 212 kg and 204 kg for the third group). The calves probably take also some carrots and more hay, but it was an uncontrolled variable that distorted the results. The design of the cages didn't allow separating the feed from the cow and for the calf and for this it was not controlled.

Another conclusion that can be drawn, according to Krohn (2001), is that growth is more uniform in the case of artificial reared calves than in the suckling system. Looking at standard deviations (in the appendices), we can see how in suckling group between 75 and 105 days of age the variances are higher than in the non-suckling group (10,5 vs 12,8, 11,7 vs 15,6 and 11,4 vs 19,5 for ages 75, 90 and 105 respectively). Hierarchies between calves are established and in the suckling group getting the milk is much more dependent on calf's attitude than in bucket-fed calves.

A surprising result was found looking at the finally available data about the post-weaning growth of groups 1 and 2. In a few weeks, calves from both groups got similar values, even greater for the suckling group as can be seen in the graphic of the average growth, meaning that suckling group reached the average, so growing a little bit faster. It seems that nursing milk have probably created a physiological situation that had a long-term effect on growing potential. Previous work studying the post-weaning growth reached the same conclusion (van Leewen, 2004) stating that animals "compensate" for a lower BW at weaning by increased growth the first month post-weaning.

The growing potential is also dependant of the initial growth. Calves that began with little weight never exceed the ones that start from greater weight. This is

the case, for example of the twins. With the same age they have little weight and for this they cannot reach the weights of single ones. Maybe the potential and also the hierarchies established led the bigger calves at the beginning be the better calves at the end.

4.2. HEALTH INCIDENCES

Few health incidences happened and for this it's difficult to reach any conclusion. Respiratory problems of calves 8135 and 8136 cannot be attributed to the treatments. They were in the same group, thing that reinforces that the independence between calves cannot be assumed and that the group is the experimental unit.

The infection in the umbilical cord of calf 8072 can be due to a problem of cross-suckling. This calf was in a non-suckling group and maybe because suckling in these calves was not allowed (behavioural deprivation) it leaded to cross-suckling, and this caused the infection. This calf finally died but it cannot be directly concluded that the main cause is the cross-suckling caused by deprivation of suckling, but anyway this may be a possibility.

4.3. ECONOMICAL EVALUATION

As said before, doing an exact economical analysis in the conditions of the farm is not an easy thing. But from the data we got, we can get an approach to the main costs of each rearing system.

In the three cases the suckling option resulted cheaper than the artificial one. But there has been a lot of difference between the three options. In bucket feed calves the costs of the powder milk are clear. Working hours can be difficult to estimate, but it seems clear that preparing the milk, getting it at the right temperature and give it to the calves take more time than giving feed to the cow at the time is given the feed to the calves. So it is an actual cost that has to be included.

The suckling option is more variable in costs. It depends on the costs for acquiring, transporting and maintaining the nurse cow. Feeding costs are the main part of maintaining the cow, but other costs can also be important. In our case there where no vet costs, but this can also be another cost. In Aver Heino (KWIN, 2005) they have calculated average costs and vet costs are € 36,5 on average for a suckling cow. It would rise € 12 the cost to rear a suckling calf, that is not very significant.

The cost to buy the cow is another value that can be very variable. Average costs for a suckling cow are € 1220 (KWIN, 2005). In our experiment the cows used were culling cows and for this they were cheaper. They are cows that are not good in dairy farms and are sold to the beef sector. Then the important variable to determine its price is the weight they have and we saw that it has been changing but around the initial weight and at the end of the experiment the weight was the same that when the experiment started.

This links with a debate that there is in the Netherlands about fattening culling cows ("*Biologisch Rundvlees: Vraag en Aanbod in Evenwicht!*" booklet 2004). This can result profitable taking into account some things as the breed of the cow

(crossbreds are better in meat than pure Holstein-Friesian) and the season in which they are sold (in summer meat price is higher) you can even earn money feeding culling cows during a period.

It also depends a lot of the availability of cows. Transportation costs can be very variable. Get cows with good maternal behaviour that can rear calves can be difficult and even cows that result not able to rear calves can be acquired.

In our case, calves quickly started to suckle and cow let them do it. Cow 7181 resulted a very good mother with good management, so they had been able to rear three groups. Cow 6181 showed difficulties for management and was sold after rear one group, and the price got was not as good as it could be, but anyway, her group was more economical than the artificial reared. Using suckling cows, that, as we said, the costs can be around € 1220 can be a good option, because they probably can be able to grow 3 or 4 groups, with the same or better results than culling cows, and they surely could be sold for at least € 600 the standard price of a culling cow (KWIN, 2005). Then in a 91 days trial costs would be around € 191, taking into account also the feed, so there will be still almost € 34 for calf (costs for artificial reared calf is € 224) to pay vet costs, transportation costs and other possible costs that, dividing for three groups of three calves, couldn't hardly reach this.

5. CONCLUSIONS AND RECOMMENDATIONS

The conclusions from our study, in the conditions of the experiment and for organic production, are the following:

- Multiple suckling system has resulted in a successful way to rear organic calves coming from the dairy industry. Calves with previous experience in suckling can adapt to suckle from a nurse cow, and nurse cow let them suckle.

- Even the growth was not the expected, solving some limitations about the solid food intake by the calves and ensuring that the cow produces enough milk for all, calves can grow perfectly with suckling systems.

- If good maternal cows can be acquired suckling results in a more economical way to rear calves.

- Suckling cows seem to catch a physiological state that allows them to grow faster during the post-weaning treatment.

6. FURTHER RESEARCH

As said before, it is the first time that such a comparison is done for the case of rearing organic dairy male calves. Thus, this is a first overview of suckling as an option to rear these organic calves till weaning. It has resulted a more economical way, and for this it is a promising area to investigate, but more research should be done:

- More data about this system. Our experiment has analysed only a few animals in a concrete case.
- Availability, profitability and management of culling cows. These are cows that can be bought for cheaper prices than normal ones and used for a short period to rear calves.
- Suckling can be an option for dairy farmers that want to rear themselves the male calves. Then availability of cows is sure, but good management should be done, and for this more research is needed.
- A comparison in calves reared with good cows and with culling cows will also be valuable to know the disadvantages of culling cows as nurse cows.
- Future characteristics of calves reared with to systems should be examined.

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APPENDICES

EXP 1.1	1.12.2004	8.12.2004	15.12.2004	22.12.2004	29.12.2004	5.1.2005	12.1.2005	19.1.2005	26.1.2005	2.2.2005	9.2.2005	16.2.2005	23.2.2005	2.3.2005	9.3.2005
Suckling group															
7181 (cow)	612	582	590	567	563	573	583	580	580	578	573	567	530	567	567
8135 (Tw)	44	52	56	61	64	67,5	71	78	84	88	97	104	113	123	END
8136 (Tw, F)	43	52	54	58	65	67,5	70	78	85	91	98	105	113	121	END
8138	57	59	65	68	77	81,5	86	93	96	103	106	119	125	138	END
Average	*48,0*	*54,3*	*58,3*	*62,3*	*68,7*	*72,2*	*75,7*	*83,0*	*88,3*	*94,0*	*100,3*	*109,3*	*117,0*	*127,3*	
Non-suckling group															
8133	65	65	68	73	76	84	92	99	110	119	130	140	152	161	END
8134 (Tw)	43	41	47	49	49	55	61	67	73	80	90	97	106	113	END
8137	57	59	64	70	76	84,5	93	101	111	122	130	140	151	164	END
Average	*55,0*	*55,0*	*59,7*	*64,0*	*67,0*	*74,5*	*82,0*	*89,0*	*98,0*	*107,0*	*116,7*	*125,7*	*136,3*	*146,0*	

Table 1. Measured weights of the trial 1, group 1 (in kg)

EXP 1.2	22.12.2004	29.12.2004	5.1.2005	12.1.2005	19.1.2005	26.1.2005	2.2.2005	9.2.2005	16.2.2005	23.2.2005	2.3.2005	9.3.2005	16.3.2005	23.3.2005	
Suckling group															
6181 (cow)	542	529	528,5	528	514	543	548	533	530	529	561	565,67	570,33	575	END
8143	65	66	75	84	92	96	103	116	123	131	145	159	169	180	END
8144	47	49	53	57	66	69	69	73	80	84	91	99	108	117	END
8145	50	52	53,5	55	55	62	64	71	72	78	84	91	99	106	END
Average	*54*	*55,67*	*60,50*	*65,33*	*71,00*	*75,67*	*78,67*	*86,67*	*91,67*	*97,67*	*106,67*	*116,33*	*125,33*	*134,33*	
Non-suckling group															
8071	52	51	57,5	64	72	77	85	91	97	108	120	127	140	150	end 18/3/05
8072	49	49	53,5	58	64	69	77	84	91	98	106	115	126	126	end 18/3/05
8142	53	54	59,5	65	72	80	88	96	104	114	124	136	147	164	end 18/3/05
Average	*51,33*	*51,33*	*56,83*	*62,33*	*69,33*	*75,33*	*83,33*	*90,33*	*97,33*	*106,67*	*116,67*	*126,00*	*137,67*	*146,67*	

Table 2. Measured weights of trial 1, group 2 (in kg)

EXP 2	2.3.2005	9.3.2005	16.3.2005	23.3.2005	30.3.2005	6.4.2005	13.4.2005	20.4.2005	27.4.2005	4.5.2005	11.5.2005	18.5.2005	
						Suckling group							
7181	567	567	599	607	607	623	618	591	589	605	593	596	
8077	72	79	88	96	109	118	128	137	143	150	159	168	END
8080	55	56	61	66	72	78	86	92	98	103	110	116	END
8081	52	56	62	68	74	83	92	101	106	112	116	112	END
Average	*59,7*	*63,7*	*70,3*	*76,7*	*85,0*	*93,0*	*102,0*	*110,0*	*115,7*	*121,7*	*128,3*	*132,0*	
						Non-suckling group							
8076	89	96	105	115	122	138	151	160	171	184	191	out	
8078	58	65	72	79	85	91	100	109	116	121	125	out	
8079	62	67	72	78	82	89	103	111	118	129	136	out	
Average	*69,7*	*76,0*	*83,0*	*90,7*	*96,3*	*106,0*	*118,0*	*126,7*	*135,0*	*144,7*	*150,7*		

Table 3. Measured weights of trial 2 (in kg)

	9.3.2005	23.3.2005	6.4.2005	20.4.2005	11.5.2005		9.3.2005	23.3.2005	6.4.2005	20.4.2005	11.5.2005
	Suckling group						**Suckling group**				
8135 (tw)	133	155	175	196	223	**8143**	159	180	196	212	241
8136 (tw, f)	133	151	162	180	199	**8144**	99	117	142	160	192
8138	143	158	170	184	207	**8145**	91	106	121	133	150
Average	*136,33*	*154,67*	*169,00*	*186,67*	*209,67*	***Average***	*116,33*	*134,33*	*153,00*	*168,33*	*194,33*
	Non-suckling group						**Non-suckling group**				
8133	155	176	184	206	220	**8071**	127	150	161	170	179
8134 (tw)	122	128	145	149	172	**8072**	115	126		*dead*	
8137	156	185	198	217	223	**8142**	136	164	175	183	202
Average	*144,33*	*163,00*	*175,67*	*190,67*	*205,00*	**Average**	*126,00*	*146,67*	*168,00*	*176,50*	*190,50*

Table 4. Measured weights of post-weaning growth of groups 1 and 2 of trial 1 (in kg)

	Birth date	Treatment	Starting age (days)	Weaning age (d)	Age last record (d)	w30	w45	w60	w75	w90	w105	w120	w135	w150	w165	w180
8135	11.11.2004	suckling1	20	111	181	53,7	62,7	70	83,1	97	114,4	136,1	159,3	181	202,4	221,7
8136	11.11.2004	suckling1	20	111	181	52,9	62	69,3	84	98	114,1	135,6	153,4	167,1	184,5	198,1
8138	12.11.2004	suckling1	19	110	180	62,4	74,4	85,4	96	107,9	128,7	146,2	161,4	175	190,6	207
8133	7.11.2004	AM	24	115	185	65	73	85,1	102,1	123,7	146,9	156,7	174,5	184	206,7	216,7
8134	10.11.2004	AM	21	112	182	42,7	49	58,4	71,3	88,6	106	122,4	130,4	145,9	153,4	169,8
8137	12.11.2004	AM	19	110	180	61,9	74,3	91,8	111	131,4	154,7	162,2	188,7	204,8	218,7	223
8143	24.11.2004	suckling2	28	119	168	65,3	78,9	94,3	112,3	129,9	159	181,1	198,3	216,1	236,9	
8144	26.11.2004	suckling2	26	117	166	48,1	55,9	68,6	73	85	101,6	122,4	152,3	167,6	190,5	
8145	29.11.2004	suckling2	23	114	163	52	55	62,6	71,4	81,4	96,7	112,4	127	139,5		
8071	29.11.2004	AM	23	114	163	51	63,1	79,3	93,6	114,9	136,3	154,7	165,5	173,4		
8072	5.12.2004	AM	17	108	157	58,7	64	78	93	109,9	126					
8142	22.11.2004	AM	30	121	170	53	60,3	74,3	91,4	109,7	132,6	161,6	175	183,9	197,5	
8077	9.1.2005	suckling1	53	130	130			79	97,9	120,9	139,6	155,1				
8080	28.1.2005	suckling1	34	111	111		58,9	70,3	84,9	98	110,9					
8081	28.1.2005	suckling1	34	111	111		59,4	72,3	90,7	106	115,4					
8076	26.12.2004	AM	67	137	137				97,3	117	143,6	166,3	189			
8078	24.1.2005	AM	38	108	108		65	79,9	93,6	112	123,3					
8079	25.1.2005	AM	37	107	107		67,7	79,1	95	115	134					
Average suckling group			*28,56*	*114,89*	*154,56*	*55,73*	*63,40*	*74,64*	*88,14*	*102,68*	*120,04*	*141,27*	*158,62*	*174,38*	*200,98*	*208,93*
Average non-suckling group			*30,67*	*114,67*	*154,33*	*55,38*	*64,55*	*78,24*	*94,26*	*113,58*	*133,71*	*153,98*	*170,52*	*178,40*	*194,08*	*203,17*

Table 5. Calculated weights at ages: 30 days (w30), 45, 60, 75, 90, 105, 120, 135, 150, 165 and 180 days (w180) (in kg)

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower Bound	Upper Bound		
w30	,00	6	55,3833	8,14504	3,32520	46,8356	63,9310	42,70	65,00
	1,00	6	55,7333	6,63827	2,71006	48,7669	62,6998	48,10	65,30
	Total	12	55,5583	7,08654	2,04571	51,0558	60,0609	42,70	65,30
w45	,00	8	64,5500	7,91797	2,79943	57,9304	71,1696	49,00	74,30
	1,00	8	63,4000	8,67476	3,06699	56,1477	70,6523	55,00	78,90
	Total	16	63,9750	8,04533	2,01133	59,6879	68,2621	49,00	78,90
w60	,00	8	78,2375	9,59731	3,39316	70,2139	86,2611	58,40	91,80
	1,00	9	74,6444	9,85585	3,28528	67,0686	82,2203	62,60	94,30
	Total	17	76,3353	9,60644	2,32990	71,3961	81,2745	58,40	94,30
w75	,00	9	94,2556	10,54326	3,51442	86,1513	102,3598	71,30	111,00
	1,00	9	88,1444	12,79542	4,26514	78,3090	97,9799	71,40	112,30
	Total	18	91,2000	11,80010	2,78131	85,3319	97,0681	71,30	112,30
w90	,00	9	113,5778	11,67538	3,89179	104,6033	122,5523	88,60	131,40
	1,00	9	102,6778	15,62312	5,20771	90,6688	114,6868	81,40	129,90
	Total	18	108,1278	14,50723	3,41939	100,9135	115,3421	81,40	131,40
w105	,00	9	133,7111	14,38771	4,79590	122,6517	144,7705	106,00	154,70
	1,00	9	120,0444	19,46928	6,48976	105,0790	135,0099	96,70	159,00
	Total	18	126,8778	18,03423	4,25071	117,9096	135,8460	96,70	159,00
w120	,00	6	153,9833	16,01642	6,53868	137,1751	170,7915	122,40	166,30
	1,00	7	141,2714	22,54785	8,52229	120,4181	162,1247	112,40	181,10
	Total	13	147,1385	20,11453	5,57877	134,9834	159,2935	112,40	181,10
w135	,00	6	170,5167	21,64601	8,83695	147,8006	193,2328	130,40	189,00
	1,00	6	158,6167	23,02046	9,39806	134,4582	182,7752	127,00	198,30
	Total	12	164,5667	22,19190	6,40625	150,4666	178,6667	127,00	198,30
w150	,00	5	178,4000	21,44656	9,59119	151,7706	205,0294	145,90	204,80
	1,00	6	174,3833	24,90120	10,16587	148,2511	200,5155	139,50	216,10
	Total	11	176,2091	22,32525	6,73132	161,2108	191,2074	139,50	216,10
w165	,00	4	194,0750	28,47202	14,23601	148,7697	239,3803	153,40	218,70
	1,00	5	200,9800	21,10348	9,43776	174,7766	227,1834	184,50	236,90
	Total	9	197,9111	23,23615	7,74538	180,0502	215,7720	153,40	236,90
w180	,00	3	203,1667	29,06756	16,78217	130,9588	275,3745	169,80	223,00
	1,00	3	208,9333	11,91819	6,88097	179,3269	238,5398	198,10	221,70
	Total	6	206,0500	20,11872	8,21343	184,9367	227,1633	169,80	223,00

Table 6. Descriptive statistics for weights at different ages

```
Dependent variable.. suckl11           Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R           ,99187
R Square             ,98381
Adjusted R Square    ,97841
Standard Error      3,07953

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        1728,4361        1728,4361
Residuals      3          28,4506           9,4835

F =     182,25662       Signif F =  ,0009

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,876467     ,064922    ,991870    13,500  ,0009
(Constant)        24,067000    5,060191                4,756  ,0176
_



Dependent variable.. suckl11           Method.. EXPONENT

Listwise Deletion of Missing Data

Multiple R           ,99883
R Square             ,99766
Adjusted R Square    ,99688
Standard Error       ,01298

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        ,21538567        ,21538567
Residuals      3        ,00050537        ,00016846

F =    1278,59133       Signif F =  ,0000

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,009784     ,000274    ,998829    35,757  ,0000
(Constant)        42,189442     ,899763                46,889  ,0000
_
```

```
Dependent variable.. am11              Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R           ,99541
R Square             ,99084
Adjusted R Square    ,98779
Standard Error      3,10707

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        3133,6080        3133,6080
Residuals      3          28,9616           9,6539

F =     324,59661       Signif F =  ,0004

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days               1,180133     ,065503    ,995411    18,017  ,0004
(Constant)         9,310000    5,105429                1,824  ,1657
_



Dependent variable.. am11              Method.. EXPONENT

Listwise Deletion of Missing Data

Multiple R           ,99984
R Square             ,99968
Adjusted R Square    ,99957
Standard Error       ,00603

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        ,33871268        ,33871268
Residuals      3        ,00010896        ,00003632

F =    9325,99433       Signif F =  ,0000

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,012269     ,000127    ,999839    96,571  ,0000
(Constant)        37,688720     ,373217              100,983  ,0000
_
```

```
Dependent variable.. suckl12          Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R           ,99055
R Square             ,98120
Adjusted R Square    ,97493
Standard Error      3,41838

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        1829,5268        1829,5268
Residuals      3          35,0560          11,6853

F =     156,56625       Signif F =  ,0011

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,901733     ,072066    ,990555    12,513  ,0011
(Constant)        20,746000    5,616971                3,693  ,0344
_



Dependent variable.. suckl12          Method.. EXPONENT

Listwise Deletion of Missing Data

Multiple R           ,99812
R Square             ,99624
Adjusted R Square    ,99498
Standard Error       ,01726

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        ,23658934        ,23658934
Residuals      3        ,00089332        ,00029777

F =     794,53000       Signif F =  ,0001

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,010254     ,000364    ,998117    28,187  ,0001
(Constant)        39,995945    1,134071                35,268  ,0001
_
```

```
Dependent variable.. am12              Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R           ,99755
R Square             ,99510
Adjusted R Square    ,99347
Standard Error      2,21104

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        2979,7664        2979,7664
Residuals      3          14,6661           4,8887

F =     609,52206       Signif F =  ,0001

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days               1,150800     ,046613    ,997548    24,689  ,0001
(Constant)         8,784000    3,633108                2,418  ,0944
_



Dependent variable.. am12              Method.. EXPONENT

Listwise Deletion of Missing Data

Multiple R           ,99911
R Square             ,99821
Adjusted R Square    ,99762
Standard Error       ,01435

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        ,34530639        ,34530639
Residuals      3        ,00061757        ,00020586

F =    1677,42009       Signif F =  ,0000

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,012388     ,000302    ,999107    40,956  ,0000
(Constant)        36,296052     ,855702                42,417  ,0000
_
```

```
Dependent variable.. suckl2           Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R           ,99922
R Square             ,99843
Adjusted R Square    ,99791
Standard Error      1,15764

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        2562,2405        2562,2405
Residuals      3           4,0204           1,3401

F =    1911,93428       Signif F =  ,0000

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                1,067133     ,024405    ,999216    43,726  ,0000
(Constant)         10,857000    1,902196                5,708  ,0107
_



Dependent variable.. suckl2           Method.. EXPONENT

Listwise Deletion of Missing Data

Multiple R           ,99341
R Square             ,98686
Adjusted R Square    ,98248
Standard Error       ,03856

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        ,33488832        ,33488832
Residuals      3        ,00446017        ,00148672

F =     225,25286       Signif F =  ,0006

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,012200     ,000813    ,993407    15,008  ,0006
(Constant)         35,225146    2,231770                15,783  ,0006
_
```

```
Dependent variable.. am2               Method.. LINEAR

Listwise Deletion of Missing Data

Multiple R           ,99693
R Square             ,99387
Adjusted R Square    ,99183
Standard Error      2,43314

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        2880,8273        2880,8273
Residuals      3          17,7605           5,9202

F =     486,61226       Signif F =  ,0002

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days               1,131533     ,051295    ,996932    22,059  ,0002
(Constant)        13,025000    3,998057                3,258  ,0472
_



Dependent variable.. am2               Method.. EXPONENT

Listwise Deletion of Missing Data

Multiple R           ,99949
R Square             ,99898
Adjusted R Square    ,99864
Standard Error       ,01031

            Analysis of Variance:

              DF   Sum of Squares      Mean Square

Regression     1        ,31207465        ,31207465
Residuals      3        ,00031918        ,00010639

F =    2933,18456       Signif F =  ,0000

-------------------- Variables in the Equation --------------------

Variable                   B        SE B       Beta         T  Sig T

Days                ,011777     ,000217    ,999489    54,159  ,0000
(Constant)        39,239780     ,665071                59,001  ,0000
```

Table 7. Regression to adjust calves groups growth

T-Test

Group Statistics

	suckling	N	Mean	Std. Deviation	Std. Error Mean
expgrowth	,00	3	1,0122	,00033	,00019
	1,00	3	1,0108	,00130	,00075

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	6,389	,065	1,833	4	**,141**	,00141	,00077	-,00073	,00356
Equal variances not assumed			1,833	2,255	,194	,00141	,00077	-,00157	,00440

Table 8. T-test for looking significant differences between two treatments of the experiment